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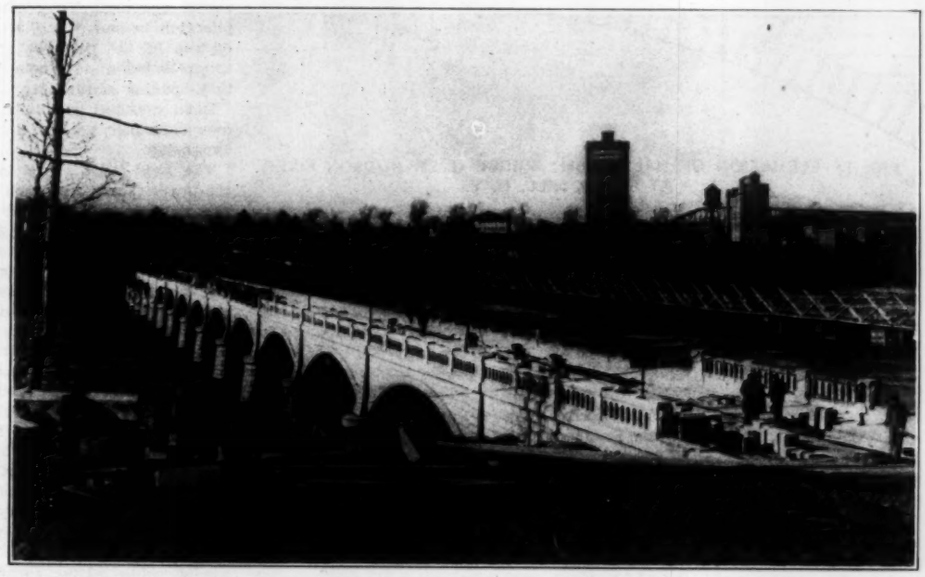
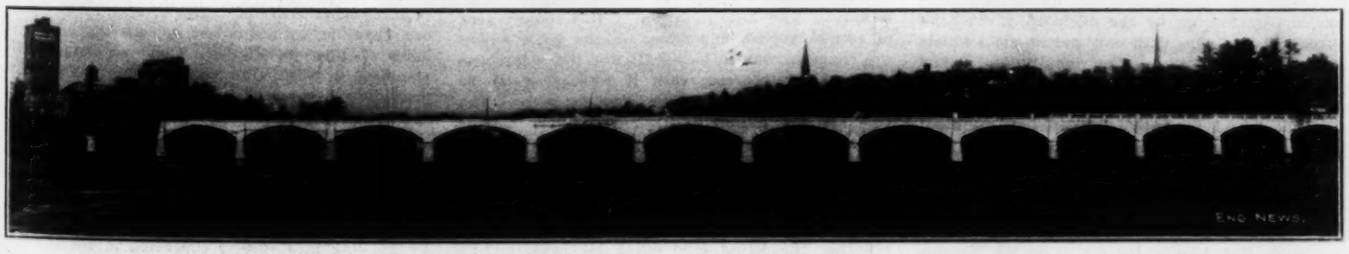
THE SANDY HILL BRIDGE OVER THE HUDSON RIVER; A LONG REINFORCED-CONCRETE ARCH BRIDGE WITH BLOCK FACING.

Some of the current problems of reinforced-concrete construction were solved in novel and effective manner in the building of a bridge across the Hudson River at Sandy Hill, N. Y., during the past year. These problems are primarily those of securing two objects: First, a good surface finish; second, economical form work, and in connection therewith rapidity and cheapness of construction. The methods adopted in attaining these objects in the case of the Sandy Hill bridge are to be outlined in this article. The bridge is an interesting structure in both design and execution. Though in a location where beauty and finish are by no means primary requisites, it has most pleasing lines and a strikingly handsome appearance. Persons not informed of its nature have taken it to be built of white marble. The rapidity of its construction is exhibited by the dates of beginning and completion: orders for beginning work were received March 1, 1906, and the bridge was opened for traffic on Jan. 4, 1907. The bridge is 35 ft. wide and 1,025 ft. long, and cost about $80,000 to build, so that the total cost is only about $80 per lin. ft. The cuts on this page show two general views of the structure, taken when the bridge was nearing completion.





REINFORCED CONCRETE ARCH BRIDGE OVER THE HUDSON RIVER AT SANDY HILL, N. Y.

The Design.

The bridge consists of a series of 15 equal arches, each 60 ft. in clear span. The piers are 6 ft. thick at the springing line of the arches, so that the distance between faces of abutments is 984 ft. The total length of bridge and abutment walls is 1025 ft. The roadway is 32 ft. 4 ins. wide in the clear between railings, and accommodates a roadway, a sidewalk, and an electric railway track. The deck of the bridge is about 24 ft. above the surface of the river. The Hudson at this point is a shallow rapid-flowing stream, with slate-rock bottom. There is a dam half a mile above, and a beautiful natural fall some 60 ft. high only a few hundred feet below the bridge, so that the variations of water level are not troublesome except in very high water, when the depth may be as much as 8 ft.

The purpose of the bridge is to afford highway communication and accommodate an electric railway between Sandy Hill on the east bank and a large new sulphite plant of the Union Bag & Paper Co. on the west bank; the latter locality has been named Fenimore, and it is expected to develop a considerable population. The line of the Delaware & Hudson Railway's Lake George branch, extending from Fort Edward north to Lake George, lies on the east bank, passing through Sandy Hill. On the same side of the river, at the falls below the new bridge, is a very large plant of the Union Bag & Paper Co. As the mill at Fenimore produces some 150 tons of sulphite pulp per day, most of which is worked up in the mill on the east bank, the importance of a connecting line is evident.

The plan to bridge the Hudson at Sandy Hill is by no means a recent one. In the early part of the nineteenth century a toll-bridge connected the east and west banks about an eighth of a mile above the site of the present bridge, on the line of the main road from Saratoga to Montreal. About 75 years ago the toll-bridge was destroyed. Later the erection of a new bridge at the same place was begun, but only the piers were built, remaining even now as a memorial of the former crossing. From that time until 1901 there was no bridge at Sandy Hill. In the latter year the Union Bag & Paper Co. constructed a temporary wooden bridge, a series of two-panel A-spans on stone-filled crib piers, about 200 ft. above the location of the present structure. This appears in the background of the view on the preceding page. It was built under authorization from the Counties for the construction of a permanent private bridge, to be open to the use of the public as a highway bridge, and the immediate construction of a temporary bridge. The temporary bridge, it may be remarked, was put up in the short space of 28 days, and when it was taken down, last winter, it was removed down to the water level within 12 days.

Before final plans for the permanent bridge were adopted, the public authorities came to an understanding with the Union Bag & Paper Co. to build a public instead of a privately-owned bridge, under a division of cost among the parties benefited. The arrangement, based on a rough estimate of $60,000 for the bridge, provided that

Washington County together with the township of Kingsbury, and Saratoga County together with the township of Moreau, were each to pay one-third of the cost, up to a maximum of $20,000, while the company was to pay one-third of the cost or all excess over $40,000 if the bridge cost more than $60,000. Actually, the company's share has about equalled the total contribution of the counties and towns.

The agreement placed the entire conduct of design and construction upon the company, subject only to approval of the plans by the committees of the two counties. Under this plan Mr. M. O. Kasson, of Sandy Hill, was placed in charge as Engineer, and Prof. W. H. Burr, of New York City, was retained as Consulting Engineer.

The conditions of the site: uniformly shallow water, rock bottom, low elevation of deck; called for a bridge of a large number of short spans. When concrete was decided upon as the material of construction, segmental or elliptic arches were dictated. A preliminary sketch design prepared by Mr. Kasson employed 60-ft. circular segmental arches of 8 ft. 6 ins. rise, with piers of substantially minimum size, and this arrangement

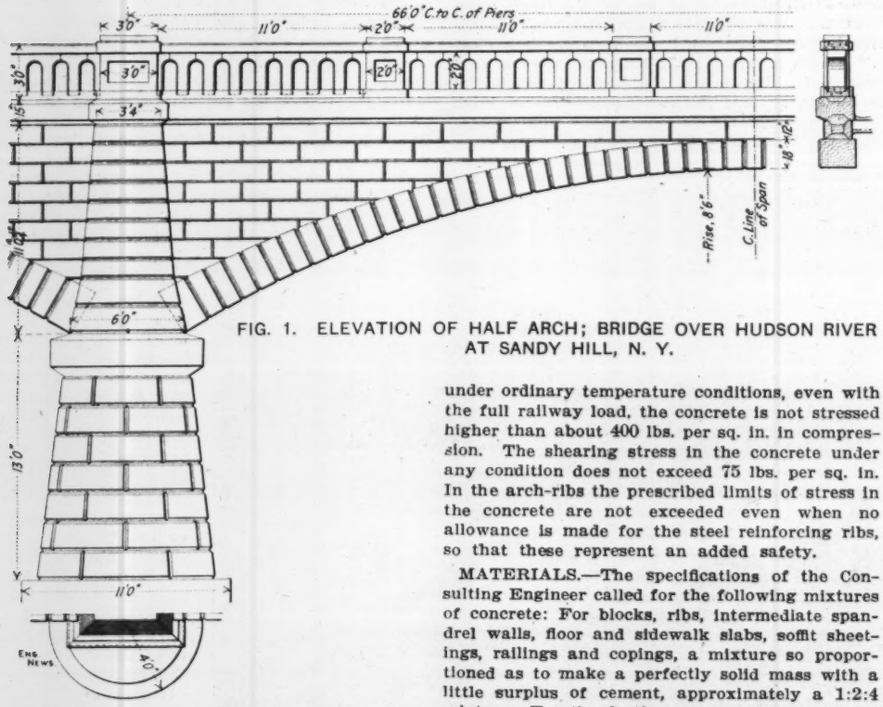


FIG. 1. ELEVATION OF HALF ARCH; BRIDGE OVER HUDSON RIVER AT SANDY HILL, N. Y.

of spans and piers was adhered to in the subsequent plans. The initial idea of a continuous-soffit arch carrying longitudinal walls was, however, departed from by the adoption of an arch segregated into ribs, with only partial soffit sheeting between the ribs. The longitudinal walls supported by the ribs carry a reinforced-concrete roadway slab. The spaces enclosed by walls, soffit sheet and roadway slab are left unfilled; electric wires, water and gas pipes will be carried through these spaces or galleries.

One of the earliest definite proposals for the construction of the bridge involved the use of separately-molded concrete blocks for the entire face work. This idea is due wholly to Mr. Kasson. Economy of construction and a good face finish were the two objects of this plan. The bridge as actually built has its external spandrel walls or face walls, the coping, most of the railing, and the entire external surface of the piers, built of molded blocks; the intermediate arch ribs and spandrel walls, the roadway plate, and the pier filling, are of mass concrete built in forms. Special bonding holes cored out in the blocks serve to bond the block work into solid walls, and the block work and the mass work into a monolithic whole. The objects aimed at by the design seem to have been fully realized. It appears now that somewhat greater rapidity and simplicity of working would have been secured by laying up the intermediate spandrel walls of blocks also; possibly, however, this would have reduced the efficiency of these walls as aids to the arch-ribs in taking the arch stresses.

The principal elements of the design of the bridge are exhibited in the drawings Figs. 1, 2 and 3, and together with certain specification details may be briefly described.

LOADS.—The bridge was designed for the following loads, besides the dead weight: Snow-load of 12 lbs. per sq. ft.; Live load of 100 lbs. per sq. ft. on roadway and sidewalk; Railway load of cars weighing with load 120,000 lbs., carried on two four-wheel trucks; and as concerns the roadway floor-plate, a truck weighing with load 24,000 lbs. on a wheel-base 6 × 10 ft. The possible variation of temperature of the structure was taken at 120° F.

STRESSES.—The structure is proportioned for a maximum stress in the concrete of 500 lbs. per sq. in., under the worst combination of load and temperature. The elastic modulus of the concrete was assumed as 2,000,000, that of the steel as 30,000,000 lbs. per sq. in. No tensile value was allowed the concrete. The design is such that under ordinary temperature conditions, even with the full railway load, the concrete is not stressed higher than about 400 lbs. per sq. in. in compression. The shearing stress in the concrete under any condition does not exceed 75 lbs. per sq. in. In the arch-ribs the prescribed limits of stress in the concrete are not exceeded even when no allowance is made for the steel reinforcing ribs, so that these represent an added safety.

MATERIALS.—The specifications of the Consulting Engineer called for the following mixtures of concrete: For blocks, ribs, intermediate spandrel walls, floor and sidewalk slabs, soffit sheetings, railings and copings, a mixture so proportioned as to make a perfectly solid mass with a little surplus of cement, approximately a 1:2:4 mixture. For the footing courses and the hearting of the piers, approximately 1:3:5 mixture. All concrete was to be "wet," rather than a "dry" mixture. The interpretation of this requirement of course varied, depending on the place where the concrete was to be used. For the mass concrete and reinforced work it was generally so soft that a man would sink in to his knees. The concrete for blocks and for railing work was somewhat stiffer. However, no tamping was done in any part of the work. For mortar (used in grouting) a 1:3 to 1:2 mixture was specified, the latter ratio if the sand be of rather uniform size, the former if it be well graded; but for pointing the joints (the outer 1½ ins.), a 1:1 mixture.

The cement used was specified to be Portland cement, tested according to the American Society of Civil Engineers' tests. The "Ironclad" brand of the Glens Falls Portland Cement Co. was employed exclusively, some 11,000 bbls. being used. Sand was to be "clean, hard, preferably of varying sizes," and could be either natural sand or the finer product of the stone crusher; natural sand was used throughout. The kind used for the facing of the blocks is a fine, smooth, quite uniform sand of a good light color. A much coarser yellow sand, of well-graded mixtures of sizes, was used for all other concrete. The broken stone used was a sound limestone. For the blocks and ribs this was run-of-crus[h] of a size that would pass through a ¾-in. scr[een]. For all other concrete 1½-in. stone was use[d].

RIBS AND INTERMEDIATE WALL[S].—The arch-ribs are of rectangular cross-section, varying from 32 × 14 ins. at the crown of the rib under the highway portion and 36 × 21 ins. at the crown of the railway portion, to 32 × 27 and 36 [×] ins., respectively, at the skewbacks. Since each rib carries only its part of the floor, the rib under the railway track are of necessity heavier than the others. Each rib is reinforced with a steel arch-rib made of four 3 × 2½ × 5-16 angles latticed on four sides; the sections Figs. 2 and 3 show these ribs completely, as also the short towers of four 4 × 4 × 7/16-in. steel angles placed under the ends of the ribs in the concrete hearting of the piers. The towers are so detailed that the steel ribs of adjoining spans are electrically continuous [except for the fact that the steelwork is bolted throughout instead of riveted].

The spandrel walls rising from the ribs are 15 ins. thick under the railway and 12 ins. under the roadway portions. Their special feature is the transverse reinforcement, which was put in on exactly the same idea as that underlying the use of hooping in columns (however, the maximum vertical load, in the case of a wall in the highway portion, is less than 4,500 lbs. per sq. ft., or about 35 lbs. per sq. in). Short bars of the Thacher patent shape, of a length about 2 ins. less than the thickness of the wall, are embedded in the wall, perpendicular to the plane of the wall, at intervals of 8 to 12 ins. vertical and horizontal spacing. They caused no delay or complication in concreting, as they were simply laid on top of the concrete at the proper level, the concrete being put in in layers to suit the vertical spacing of the bars.

Each spandrel wall is cut by a transverse joint over each pier, as Fig. 2 shows, to give room for expansion.

The soffit-sheeting, 6 ins. thick, is flush with the lower face of the arch ribs, so that except for the openings to be noted, the lower face of the arch looks like that of an ordinary full-barrel arch. The sheeting between the railway ribs (ribs 1 and 2 in Fig. 3), and between each outer rib and the adjacent face wall, is continuous, except for a narrow slot along the skewback, left as a drain from the hollow interior of the structure. The remainder of the sheeting is discontinuous, consisting of sections 5 to 6 ft. long circumferentially alternating with open spaces about equally long. The open spaces are staggered in adjoining rings, that is, the open spaces in the ring between ribs 2 and 3 are opposite the sheeting section in the ring between ribs 3 and 4. The main purpose of the openings was to make the hollow interior effectively open to the air; what small saving in concrete was secured thereby was probably offset by the additional complication of the forms.

Drain pipes from the roadway pass through the soffit sheeting near the crown of each arch. They are 4 ins. in diameter, and replace the drainage holes specified in Fig. 3. They are detailed as sketched in Fig. 9 to ensure drip without the possibility of water trickling along the arch and thus streaking the concrete.

FLOOR-PLATE.—The floor-plate, on sidewalk as well as roadway, is reinforced with transverse ¾-in. Thacher bars spaced 6 ins. These as well as the transverse bars in the arch sheeting were designed to be connected to the face-wall by hooking into staples concreted in the blocks. Fig 3 indicates this connection. A recess or pocket in the inner face of the block exposes the loop end of a U-shaped rod of ½-in. steel. The transverse reinforcing rod is bent to form a hook at the end, to engage the staple. By loading the middle of the transverse bar it is drawn into tight bearing in the staple, and the concreting holds it in that position. This plan was followed at the soffit sheeting. At the floor-plate, however, it was found simpler to core horizontal passages in the coping blocks, opening into the vertical bonding-holes cored in each block, so that the floor-plate bars could be passed through these holes and bent up, and afterward concreted firmly in place when the core holes were grouted.

BLOCK-WORK.—The block work of the face of the arch-ring, the face walls, piers, railings, etc., was planned to be so made that after placing the blocks they could be bonded together very strongly by grouting or filling with mass concrete. This was accomplished in general as illustrated in Fig. 2 for the case of the face-blocks of the piers. The horizontal and vertical joint-faces of these blocks are formed with a deep longitudinal channel, so that when a section of wall is laid up it has a complete meshwork of large passages of hexagonal cross-section through it. In addition, vertical holes are cored through each block, three in number for the pier blocks, one for the spandrel-wall blocks, furnishing further vertical passages. These passages are grouted full every four to five courses in height. The grout at the same time flows into the beds and joints of the blocks, which joints were previously calked outside and inside to retain the grout. After the grout has set, the wall is thus very efficiently tied together.

The edges of each block are beveled 45° so that the finished wall shows V-shaped joints. The bevels are proportioned to give the following widths across the V, counting ⅜-in. for the mortar joint in arch ring and piers, and ¼-in. in the spandrel-walls: Radial joints of arch ring, 2¼ ins.; all joints of pier walls, 2¼ ins.; Horizontal and vertical joints of external spandrel-walls 1¼ ins. The courses of the pier walls are 18 ins. high and are laid with blocks 6 ft. long, while those of the spandrel-walls are only 12 ins. high, and are laid with 3 ft. blocks; the widths of bevel differ to correspond. The width of arch-ring blocks is only 12 ins., the same as the height of course in the spandrel-wall, but it was thought proper to mark out the voussoirs of the arch-ring more boldly than the wall blocks, by giving them a wider bevel.

In order to make the pier walls an integral part of the load-carrying section, provision was made for bonding them to the hearting by hook-end anchors of flat steel, placed in the bed-joints as shown in Fig. 2. Two anchors per block were put in. A further bond was secured by molding in the inner face of each block four pockets wider at the bottom than at the entrance, i.e., undercut, which became filled with the mass concrete when the hearting was placed and thus formed four keys of concrete between the block and the hearting. These pockets will be further referred to when the molding of the blocks is described.

OTHER DETAILS.—The plans for the railing provided for molding the balusters in separate forms, and casting the base, top rail and posts in place. In actual work the posts were built up of some half dozen separately-molded parts, interlocking to form a firm hollow post, whose interior was later filled with concrete.

The railing of the bridge is carried outward at each end, where the paved roadway ends, in a quarter-circle tangent to the general line of the railing. This forms a widened entrance to the bridge, which gives a pleasing effect. A lamp-post is to be set on each main railing-post (the post over a pier) of the north side. The corresponding posts on the south side, along the railway track, will carry trolley posts.

The pavement of the bridge will be asphalt, laid directly on the floor-plate. The railway rails are laid on a longitudinal 10-in. channel bedded, flanges down, in the concrete of the floor-plate. The concrete is carried up flaring from the base of rail, and the recess so formed will be filled with the asphalt of the pavement. The surface of the road is to have a transverse crown of about 2 ins. It is drained at the center of each arch by three 4-in. drains, one in each gutter and one in the center line of the railway track. These drains are tile pipe passing through the floor-plate and the soffit sheeting.

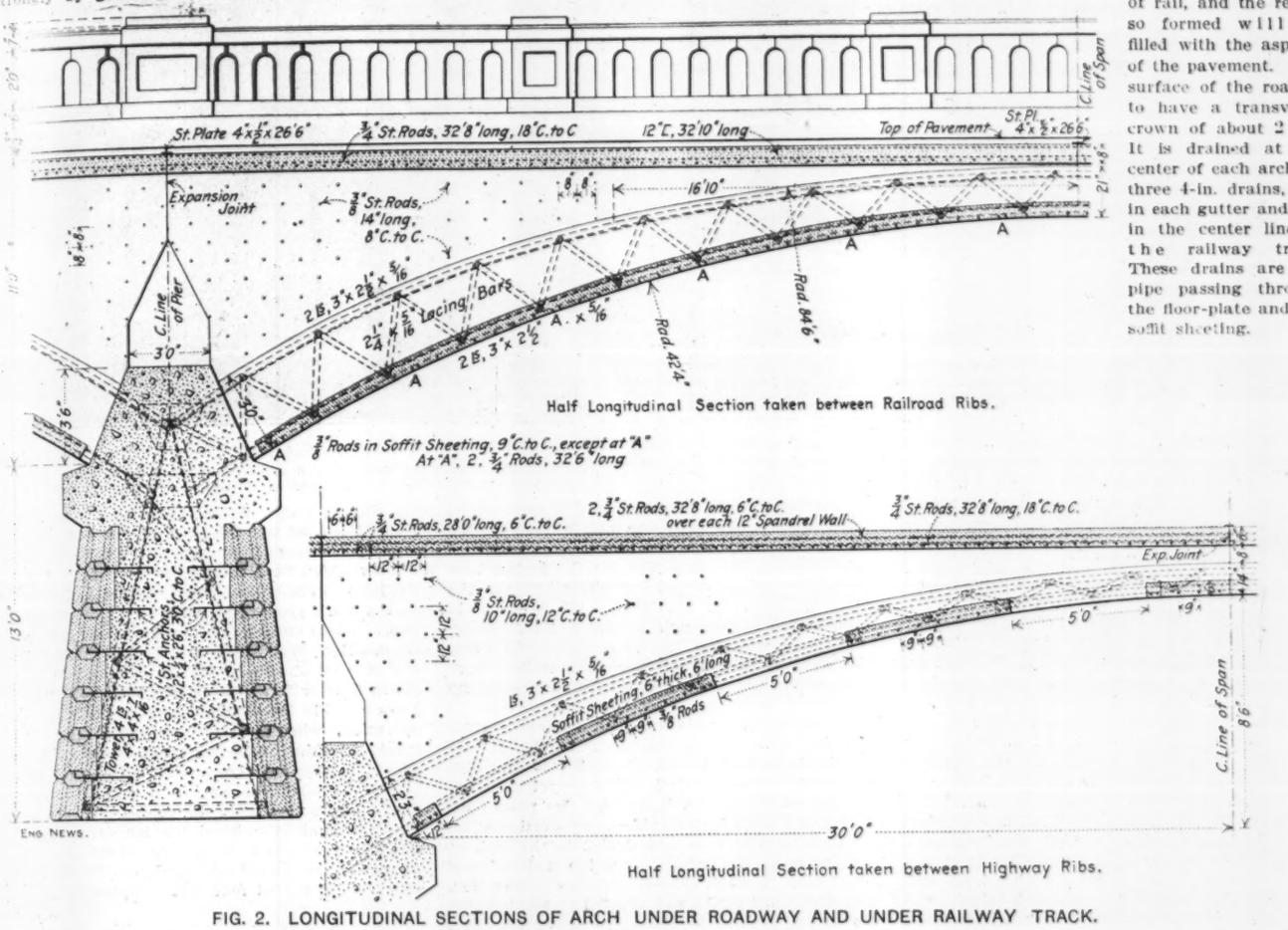

St. Plate 4"x1½"x 26'6"
¾" St. Rods, 32'8" long, 18" C. to C
12"I., 32'10" long
Top of Pavement
St. Pl. 4"x½"x 26'6"
C. Line of Span
Expansion Joint
⅜" St. Rods, 14" long, 8" C. to C.
16'10"
C. Line of Pier
30"
2 B, 3"x 2½"x 5/16"
Lacing Bars
Rad. 84'6"
Rad. 42'4"
Half Longitudinal Section taken between Railroad Ribs.
⅜" Rods in Soffit Sheeting, 9" C. to C., except at "A"
At "A", 2, ¾" Rods, 32'6" long
¾" St. Rods, 28'0" long, 6" C. to C.
2, ¾" St. Rods, 32'8" long, 6" C. to C. over each 12" Spandrel Wall
¾" St. Rods, 32'8" long, 18" C. to C.
Exp. Joint
⅜" St. Rods, 10" long, 12" C. to C.
15, 3"x 2½"x 5/16"
Soffit Sheeting, 6" thick, 6' long
⅜" Rods
5'0"
30'0"
Half Longitudinal Section taken between Highway Ribs.
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FIG. 2. LONGITUDINAL SECTIONS OF ARCH UNDER ROADWAY AND UNDER RAILWAY TRACK.

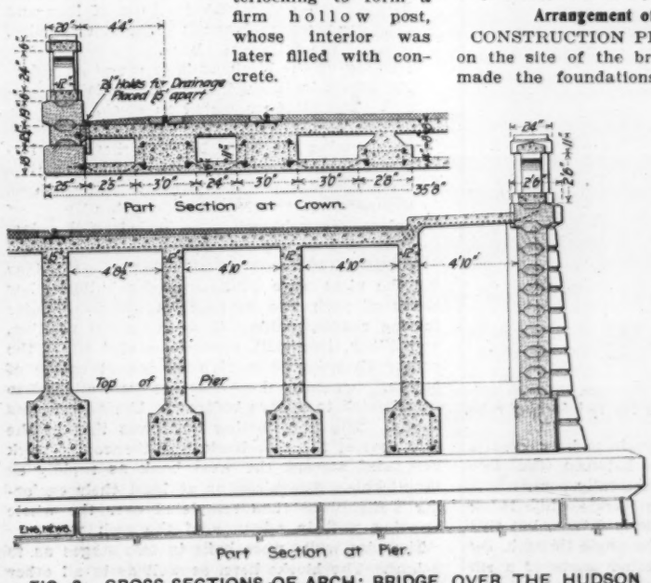


FIG. 3. CROSS-SECTIONS OF ARCH; BRIDGE OVER THE HUDSON RIVER AT SANDY HILL, N. Y.

Arrangement of Construction Work.

CONSTRUCTION PLANT.—The shallow water on the site of the bridge and the good bottom made the foundations a simple matter, which could be disposed of in a short time. The very earliest work to be started, therefore, was organizing the production of the blocks with which the pier walls were to be built. This was taken in hand immediately; the order to build the bridge was given on March 1, 1906, and on May 4, 1906, the first block was set. For the manufacture of the blocks a brick shed-building about 75 × 120 ft., a few hundred feet from the bridge, was rented. Here the forms were made, part of the stock of cement, sand and stone stored, and the blocks cast and stored for 24 hours. This plant was required, during the main part of the work,

FIG. 4. VIEW OF PIER WORK, LOOKING TOWARD EAST BANK.

Construction trestle at extreme left. In the background is the derrick used for laying up the pier walls, on a steel-pile platform loaded by water-barrels.

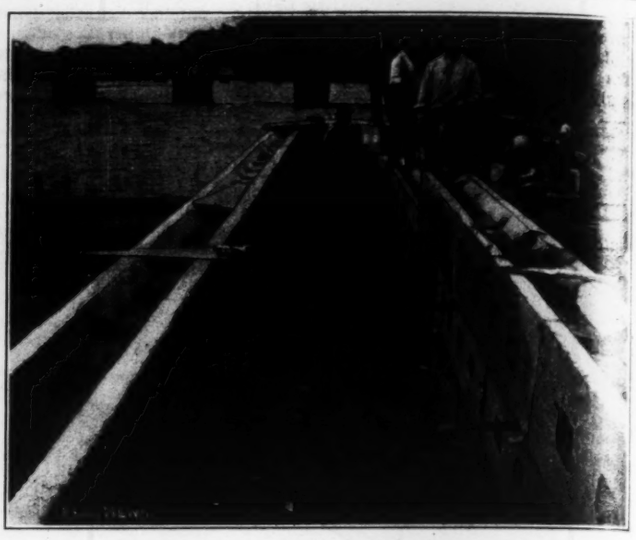


FIG. 5. CONCRETE BLOCK WALLS OF A PIER UNDER CONSTRUCTION.

The vertical holes through the blocks are for grouting the wall. The holes on the inner face are cored dove-tails for bonding blocks and hearting together.

to produce nearly 100 blocks per day. A home-made jib crane, a second-hand Ransome mixer and a band-saw were the only machines installed here.

After the piers were built it was found that the steel reinforcing ribs of the arches, for reasons of both cost and conditions of delivery, could not be obtained ready fabricated from a bridge shop, and it became necessary to do the work on the ground. The angles and flats were therefore bought plain. A small timber shed was built, to furnish a cover for the work, and under it was installed a motor-driven punch and a hand-power angle-bending machine built up on the ground. The latter, which proved very effective, is sketched in Fig. 4. It consists of three vertical shafts held in a timber frame fitted with adjusting tie-rods so that the middle shaft can be moved toward or from the plane of the other two; the upper end of this shaft is fitted with a head and capstan bar for turning. On each shaft are mounted two 12-in. coupling flanges, whose faces are separated by about ¾-in. The three sets of flanges constitute a triple-roll bending group.

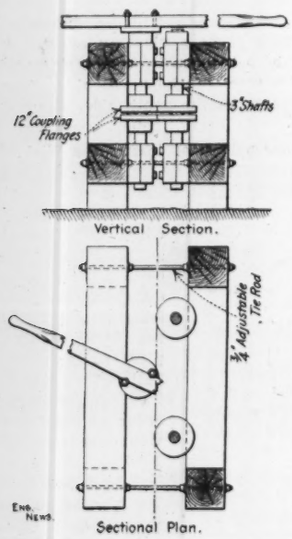


Fig. 6. Rig for Curving Angles for Reinforcing Ribs.

The outstanding leg of the angle to be curved is passed into the ¾-in. space between the two flanges of the roll, which successfully counteracts the tendency of the angle to buckle while being curved. The middle roll alone is driven, but this was found sufficient to pull the angle through. By means of this machine the inner angle of a rib was curved by trial to a templet scribed out full size on the ground. The line of the outer angle, which is three-centered, was also scribed on the ground, the lengths of the lacing bars measured from this lay-out, and jibs for the lacing bars made. Later, in assembling the ribs over the centering, the inner angles of a rib were put in place, bolted to the angle towers and blocked up to exact position, and the outer angles, which had been bent to an approximate mean radius, were then drawn into correct shape by connecting up the lacing bars.

A construction trestle was built across the river adjacent to the bridge site at the north. It carried home-made flat-cars, about 3½ × 6 ft., with 36-in. gage. The trestle is rather novel in make-up, as the sketch Fig. 5 shows. The posts consist of old 4-in. boiler tubing, set vertically on the rock; a 1-in. hole was drilled in the rock at the center of the tube, to receive a 1-in. steel dowel pin. A small quantity of cement was then poured down the tube and allowed to set, bonding the dowel, rock and tube quite firmly together. Pairs of 3 × 10 timbers were then clamped across the two tubes of a bent, as sketched, by two bolts at each end, and held up by a tie-rod hooked over the top of the tube; track stringers were laid directly on these thwarts. This trestle conveyed and distributed along the bridge all material and supplies. It was served by a derrick on the east bank, to which led a narrow-gage track from the block-making house. The trestle successfully withstood high-water with its crop of logs and debris. Ice pressure does not occur at this point, because of the falls just above.

In laying up the block walls of the piers, a derrick-platform built much like the trestle was employed. The platform rested on steel tube posts like those of the trestle, tied together by double joists clamping the tubes between them. A derrick was mounted on a pair of distributing timbers on this platform, of such size and reach as to command the trestle and yet reach all parts of the pier. Water-barrels were loaded on the platform to increase its stability.

DESCRIPTION OF THE WORK.—Footings for the piers were constructed by building low boxes of such size as to form the rectangular footing course, sinking these in correct position, and filling them with concrete leveled off at the proper elevation to receive the lowest course of blocks. Generally these footings were allowed to set about 3 to 6 days before the block work was begun. The first footing built was that of the pier nearest the east bank, and thence the work proceeded toward the west bank as rapidly as practicable. The piers, or at least their enclosing walls, were thus completed over the whole crossing well in advance of the arch work.

The pier walls were built in two stages as to height. The blocks here, as well as in all other block work on the bridge, were at least a month old when placed. After the bottom course was set and leveled up, the next course and all succeeding courses were set on wooden spacing wedges which fixed the thickness of the bed-joint. All joints were calked tightly inside and outside, as the work progressed, with strips of paraffined paper, waste cuttings obtained without cost from the nearby paper mills. As the blocks were laid, the anchors shown in Fig. 2 were put in place. When four or five courses had been built up, the holes cored in the blocks were grouted in a single operation, whereby also the joints were filled, leaving nothing to be done to complete the wall except taking out the calking strips and pointing up the outside of the joints. Upon completion of the entire pier wall, the coping was concreted in place against finished wooden forms for the straight parts and composite wood and iron forms for the curved end sections. In the latter, the vertical curved face was composed of a strip

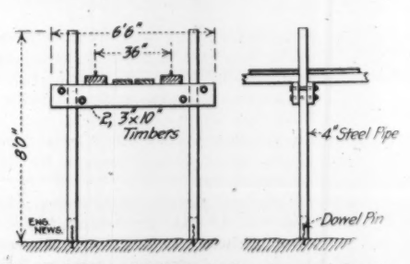


Fig. 7. Cross-Section of Construction Trestle.

of ⅛-in. steel bent to the circular curve and screwed to the wooden bevel and top sections. The coping as cast formed a ring around the outside of the pier, the entire interior rectangle, 4 × 32 ft., being left open to enable the inside forms to be removed and the concrete hearting later filled in.

The steel towers carrying the arch reinforcing ribs were built up in the hollow of the piers, and stone-bolted in correct position. The hearting concrete was not put in, however, until the adjacent arch ribs and soffit sheeting were finished.

The rapidity with which the pier walls could be built by the use of blocks and the construction plant above described is best illustrated by the fact that in one case the entire lower half of a pier was built up in half a day.

The centering provided for the arches followed closely the design of the Consulting Engineer. It consisted of unplaned transverse lagging resting on stringers cut to the curve of the intrados which were supported by posts close to the pier and four sets of intermediate posts. Between the caps of the posts and the cross sills of the curved stringers there was at each post a pair of maple

...s, tapering about 1 to 12. These worked ... satisfactorily in easing off the centers. The ... of the centering footed on small concrete ... about 2 ft. high molded on the rock bot... square boxes. The top face of the lagging ...overed with paraffined wrapping paper; in ... sections, where this was not available for ...oment, tar-paper was used. The soffit of ...nished arch is as smooth as is generally ob... with planed matched lagging. Better finish could have been secured, but as the river is not navigable this was thought to be not worth while.

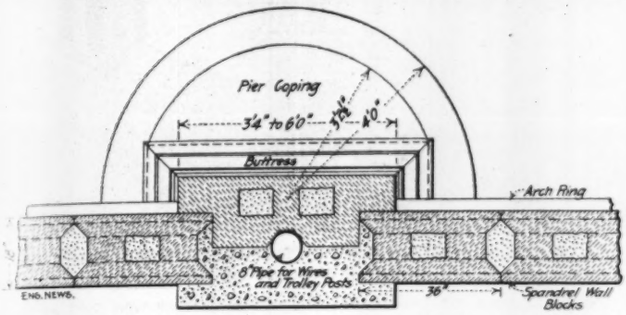


FIG. 8. HORIZONTAL SECTION THROUGH BUTTRESS OVER PIER.

Four complete spans of centering were used. Generally two completed arches, one arch in course of construction, and the next ahead, were in centering at any given time. This arrangement distributed the residual thrust of the finished arches among several piers and several sets of centering, a rather important point in view of the narrowness of the piers and the absence of occasional wider piers (abutment piers). It also allowed the centering to be left in place for about a month after concreting an arch. Generally the centers were struck after four to five weeks, but in several cases they were removed as early as 18 days after the ribs had been filled with concrete. In no instance was any deflection noted when the wedges were driven out.

Upon completion of the centering of two spans, the external buttresses over the pier between were built up. These buttresses are composed of blocks, and lap 6 ins. over the adjoining spandrel-wall blocks; they have a shallow backing of mass concrete, which was placed later, after the completion of the arch itself. The blocks of the buttresses were laid with careful attention to vertical profile and to thickness of bed-joints, so that they could be used as guides for the spandrel walls, making it possible to lay these up rapidly with a low grade of labor. A horizontal section through a buttress, Fig. 6, shows the lapping of buttress blocks over spandrel-wall blocks, and the position of an 8-in. tile pipe which was concreted in behind the buttress for wires or pipes leading to the lamps and trolley posts.

When the centering of a span was completely assembled and construction of the permanent work ready to begin, the arch-ring blocks (of the two faces of the arch) were laid, and upon these the external spandrel walls, also of blocks, were built; grouting was done every fourth to sixth course, as in the case of the pier walls. The steel ribs having previously been erected, the transverse reinforcing bars of the soffit sheeting were hooked in place. Then the upper forms for the soffit sheeting and the side forms for the arch-ribs were built up, the ribs being closed off at the springing line, since the concrete hearting of the piers had not yet been put in. After the ribs and soffit sheeting were completed, the pier was filled was mass concrete through the opening in the middle of the pier coping. The filling was done generally in two operations, so as to reduce the outward pressure of the soft concrete on the walls of the pier. This concrete was carried up against the ends of the ribs and finished as shown in Fig. 2. Form walls were then built up for the five intermediate spandrel walls, and these walls were concreted in layers, their short transverse reinforcing rods being laid in during the progress of the concreting as already noted. Finally, the roadway slab, and later the sidewalk slab, were concreted, and the vertical holes in the spandrel-wall coping, into which the reinforcing rods of the slab enter for their end anchorage, were grouted. The surface of the sidewalk was leveled off, marked and jointed in blocks about 4 ft. long, and indented with a marking roller. The railing work was left for a later period, being done as one job for the entire bridge.

CONCRETING IN FREEZING WEATHER.—A considerable amount of the reinforced concrete work near the west end of the bridge was done in early winter in temperatures well below freezing [winter temperatures in Sandy Hill down to 30° below zero being experienced]. In freezing weather two devices were used to prevent injury to the concrete: heating the sand and stone, by means of an improvised iron heating table, and heating the work being concreted. The latter was done by burning under the arch in progress two coke fires in open cylinder stoves, and confining the heated air by side lagging on the two outside ribs of centering. This lagging can be seen in one of the views on the first page, in spans 4 and 5 from the west end. It is 1-in. wood sheathing about 10 to 12 ft. long, forming with the soffit lagging a hood having no upward openings except the frames which formed the openings in the soffit sheet. By this means concrete was placed and maintained uninjured in arch ribs, soffit sheet and spandrel-walls with success at temperatures of 20° F.

Manufacture of Blocks.

The excellent success of the block work is perhaps the most interesting feature of the construction of this bridge. Together with the well-planned lines of the structure, which combine harmonious proportion and studied adaptation to the use of block facing, it is largely responsible for the coincident low cost and esthetic appearance of the bridge. It enabled the constructors to obtain a concrete surface fine-grained and even in texture, fairly uniform in color, and as durable (so far as present experience indicates) as the body of the concrete itself. The views herewith, especially Figs. 11, 13 and 15, give a suggestion of the surface obtained.

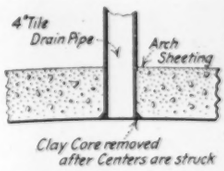


Fig. 9. Finish of Drain Pipe at Soffit of Arch.

The block making was throughout planned on the basis of having the showing face at the top in the form. This face was finished by striking off the excess concrete material with a wooden straight-edge laid across the form in contact with the upper edges of the side-pieces and drawn along from one end to the other, crowding the excess material along ahead of it. The face produced by this treatment showed no roughness or porosity; hair-cracking generally was absent, and where it did appear it was only a very fine veining which seemingly did not have any appreciable depth. Sometimes, after the use of the straight-edge, the edge of a trowel was used to float the surface back in a similar manner, to remove slight waviness in the face. No troweling of the usual kind was done. It is the opinion of the Engineer-in-charge that the freedom from hair-cracking is largely due to the non-use of the trowel, and that what little veining did occur is probably chargeable to the use of a second tool after once passing the straight-edge over.

Reference has been made to the special kind of sand used for the face portion of the blocks. This sand, mixed in a 1 : 2 mortar, rather wet, was filled in on top after the form had been filled within about one or two inches with 1 : 2 : 4 concrete of the other grade of sand and ¾-in. stone. The face material, which had a very smooth, creamy consistency, was filled in to give a slight surplus, then the straight-edge was passed over the top, brushing off all material above the exact level, and the block in its form was set aside to dry. After 24 hours, generally, the form was taken apart, and the block lifted out by a rope sling put through the holes cored in the block;

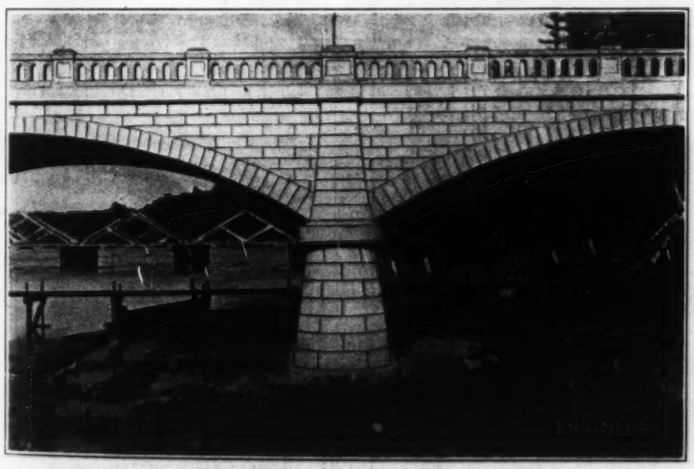


FIG. 11. PIER DETAIL OF SANDY HILL BRIDGE.

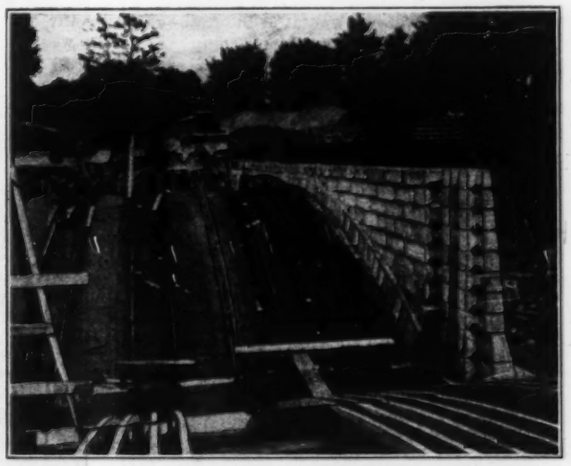


FIG. 12. AN ARCH BEFORE CONCRETING; STEEL RIBS AND SOFFIT LAGGING IN PLACE.

The holes on the inner faces of the arch blocks are recesses containing projecting staples to which cross rods in the soffit sheet are hooked. The ribs of the centering are 3 x 10 timbers, with 2 x 4 sticks cut to the curve of the intrados nailed to them; this arrangement obviated cutting the large timbers.

FIG. 13. ARCH WORK IN PROGRESS.

The pier in foreground has waxed-paper calking still in place in four upper joints.

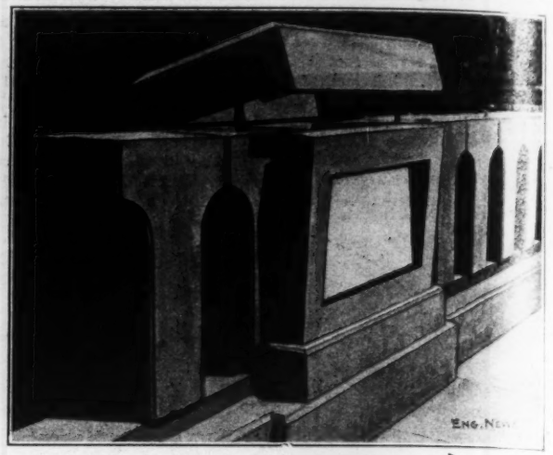


FIG. 14. RAILING POST WITH PARTS SPREAD APART TO SHOW METHOD OF CONSTRUCTION.

it was then put on a small flat-car and run out into the open, where it was piled and left for about four weeks, with frequent sprinkling.

The forms for all blocks were built up of 2-in. white pine, dressed and edged. Beveled maple strips on the upper edges, projecting inward, served to shape the beveled joint-edges. Bolted tie-rods held the sides of the form together. Before the first use, the form was knocked down and boiled in a bath of hard paraffine wax for six to eight minutes; this gave a non-adherent impregnation which lasted for the entire period of use of the form (some forms were used about 100 times each), with no other treatment than brushing the inner faces before each use with kerosene containing a little paraffine wax.

The forms for the arch-ring blocks were built from full-size measurements, the arch-ring being drawn out in full size on a wall of the block-making shed. The measurements for the buttress block and the pier block forms were obtained similarly.

As noted earlier, the blocks generally are deeply channeled on their horizontal and vertical joint-faces, and have vertical grouting holes cored through them (Fig. 16). The channels were produced by blocks screwed to the inside of the form. The grouting holes, in number 1 or 3 per block, were cored out by laying waxed-paper bags filled with sand in the mold. These holes, vertical in the block, were horizontal in the form, as the block was molded with the front side up. As the concrete was filled in, the bags, filled with sand and tied, were laid in when the concrete reached the proper level, and were pressed by hand roughly to the intended shape of the hole. They remained in the block until this was removed from the form (after 24 hours), when the bag was torn open, allowing the sand to run out, and the paper pulled out of the hole.

The dovetails on the inner faces of the pier blocks (see Fig. 5) page 500, were also cored out by sand-filled bags; a smaller bag was used, and filled and tied to give it a globular shape instead of the prismatic shape of the cores of the grouting-holes. The dovetail recess thus produced is very satisfactory for its purpose, being an irregular recess generally about 6 ins. across at the bottom and 4 ins. at the mouth, with a depth of 4 to 5 ins.

A different method was employed to form the recesses for staples in the inner faces of the arch-ring blocks. The staples in question are ½-in. steel rods bent to a U-shape, and embedded horizontally in the block so that the bend of the U is nearly flush with the inner face of the block. A shallow tapered recess, about 6 ins. square on the outside by 3 ins. deep, is cored in the concrete around the head of the staple, exposing it sufficiently to allow hooking into it the cross-rods of the soffit-sheet. The recesses were made by cores of a plaster-of-Paris mortar set in the form, and these cores served at the same time to hold the staples in proper position while the form was being filled. To make these cores, recesses like those desired in the blocks were cut in a pine timber, in a row of about a dozen. Holes were bored into the timber in the bottom of each recess to take the legs of the staples and hold the head of each up in the recess. The recesses were then filled with a 1 : 10 plaster-of-Paris mortar. When this had set, the cores, with the staples now imbedded in them, were removed, ready for use in the block forms. When the concrete block containing such a core had set, the plaster of the core could be dug out easily with a pick of metal or even wood, leaving the staple exposed as desired.

The method of finishing the face of the block, already described, was used not only for the plane faces of the blocks in the arch-ring, the spandrel-walls and the sides of the pier, but also for the convex faces of the blocks in the semicircular ends of the piers, and for the concave faces of the blocks in the abutment walls. The railings at the abutments are carried outward in a quarter-circle, and the abutment side-walls follow this curve until they meet the slope of the banks. These concave blocks were molded in forms which had been used for the regular spandrel-wall blocks, the sides of these forms (corresponding to top and bottom of block) being cut down with a draw-knife to the concave circular shape of the abutment blocks. The forms for the curved pier blocks, on the other hand, were built specially for the purpose, with sides whose upper edge was curved to the proper radius (averaging 3 ft. 10 ins.) for the curve of the pier end. A somewhat stiffer face mortar was used in these convex blocks, but the result obtained is equally good.

The pier-coping, as already noted, was cast in place. The straight vertical sides and the bottom bevel were formed against paraffined wooden surfaces, as was also the lower beveled face of the semicircular ends. The cylindrical (vertical) face of the ends of the coping, however, was formed against a steel plate bent to the proper curve and screwed to the wooden sections of the mold.

The coping of the spandrel-walls, on the other hand, is built of separately-molded blocks. In these the outside vertical face was at the top in molding, and was finished the same as the regular blocks. The upper and lower beveled faces were formed against beveled pieces screwed to the side of the form. The inner face was at the bottom of the form, and this as well as the beveled surfaces show characteristic pitting and roughness, requiring brushing over with cement wash when in place. The coping blocks are not separated by V-joints, but have their vertical joints pointed up flush, as will be seen from the views.

RAILING CONSTRUCTION.—The balusters of the railing and the individual pieces of the posts were cast in forms, while the base and hand-rail were molded in place; the posts, which contain an 8-in. pipe for wires, etc., vertically in the center, were filled with concrete after assembly. The molds for the balusters were composed of wooden front and back sections, and cast-iron pieces for the curved sides. At first they were

FIG. 15. VIEW OF COMPLETED RAILING.

Cap and base rails cast in place; joints of balusters pointed with cement mortar; post filled with concrete, and cap block cemented on.

molded upright, as they stand in the railing, but it was found that the form was very difficult to remove. The expedient of molding them upside down was then resorted to, with success, the forms coming off easily; this is explained by the shrinkage being downward, away from the incurving sides of the form when in the inverted position. The surfaces obtained, however, are rough and pitted, in contrast to the surface obtained in the regular block work. It has been

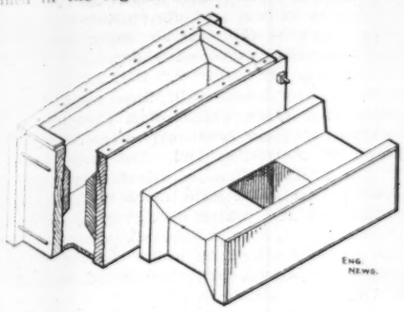


Fig. 16. Typical Block and Block Form.

necessary to brush them over with cement wash to give a passable appearance. Figs. 14 and 15 indicate the general effect.

The parts of the railing posts were all molded by the face-up method, with the same excellent results as in the wall blocks. They comprise seven pieces: a square base, recessed to receive the side panels; two side frames (4 ins. thick in the posts over piers, and 2 ins. thick in intermediate posts), the opening in the center of each of which is rabbetted out on the back like a picture frame; panels 2 ins. thick fitting in these rabbets; a cap piece with central opening through which the post is filled with concrete; and a plain cover plate which closes this opening. The cap piece is recessed on its under face to fit down over the side frames, and on its end faces to fit the outline of the hand-rail (Fig. 14). The side frames are held apart and the space between them closed off on the sides by a half baluster, as clearly shown in Figs. 14 and 15.

The way in which the railing is built up is shown by the sketch Fig. 10. Upon the coping, which has a longitudinal channel in its upper face, a rough strip of concrete, a in Fig. 10, is formed. Upon this the balusters are set when the posts at either end of the section are completed. Forms are then clamped to the sides of the balusters for the base b and the hand-rail. The top of the hand-rail is swept off by a suitably-shaped templet like the faces of the regular wall blocks, producing a smoothly-finished surface.

PROVISION FOR EXPANSION.—The concrete of the arches is continuous from abutment to abutment. The spandrel-walls all have open joints over the piers. In the case of the face walls the lapped connection between buttress and wall (Fig. 8) forms a slip-joint for this purpose, while in the intermediate walls there is a plane of separation over the center of each pier (Fig. 2). The roadway plate and the sidewalk are separated in this same plane by a construction-joint extending from railing to railing. The railing has free expansion between the posts, as the base and hand-rail are molded against the finished posts and adhere but little.

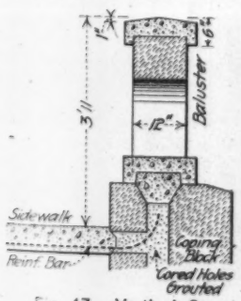


Fig. 17. Vertical Cross-Section of Railing.

These arrangements have proved adequate to care for all variations in temperature between 20° below and 70° F., the highest temperature yet experienced this season. No cracks have appeared in any part of the arches, walls or floor-plate. One of the hand-rails has cracked across, close to one of the posts, but no other expansion or shrinkage damage has been noted. The Engineer-in-charge reports: "The dry joints in the roadway slab over the piers opened 3-16-in. at 10° below zero. We have been unable to note any deflection of the arches."

As already stated, the preparations for building this bridge were begun March 1, 1906. On May 4, 1906, the first block was set in place. On Jan. 4, 1907, the roadway and sidewalk were opened for traffic, although the paving was not in, only a few panels of the railing were completed, and no railway track had been laid. By the present time practically all the railing and the curved approaches beyond the abutments, and the track, have been completed. The pavement will not be put down until summer.

The bridge was constructed entirely by day-labor, under the Engineer-in-charge, Mr. M. O. Kasson, of Sandy Hill. No skilled concrete men or masons were employed, but the entire force, excepting some carpenters, was organized from unskilled laborers. The wages were about $1.60 to $1.75 per ten-hour day for laborers, and $2.50 for carpenters. The total cost, under this method of working, will exceed $80,000 by a small amount, but from this should be deducted some extra expenditure caused by the desire to rush the work so as to turn traffic away from the old temporary bridge as soon as possible on account of the dangerous condition of the latter. Making this deduction, the total cost may fairly be put at $80,000. The estimate was $72,000, excluding engineering fees and superintendence, which figure has been exceeded but little.

RESTRICTION OF HEIGHT OF BUILDINGS in San Francisco was incorporated in the new building ordinance adopted after the earthquake and fire of April, 1906. Buildings of the first class were by this ordinance limited to a height of one and one-half times the width of the street on which they abut. While the recollections of the earthquake probably had some influence in causing the insertion of this provision, it was to a great extent due to the desire that certain very narrow streets should be widened. This effect has not been secured by the restriction on height, and therefore the clause has now been repealed.

GROWTH IN THE SIZE OF FREIGHT STEAMSHIPS is very much less than in steamships designed for passenger service. The following statement regarding this is taken from a paper by Mr. S. J. P. Thearle, read before the Institution of Naval Architects of Great Britain:

The average gross tonnage in the year 1870 of the cargo steamers then afloat was about 870 tons, and the cargo steamers built during that year had an average gross tonnage of 1,050 tons, cargo steamers of 1,100 to 1,400 tons being very common. In the year 1880 the average tonnage of cargo steamers then afloat was about 1,330, while the average size built in that year was about 1,580 tons, steamers of 1,200 to 2,000 tons being common. The average tonnage of the cargo steamers afloat in 1890 was about 1,500 tons, and that of the steamers built during that year was about 2,150 tons, a great many of the steamers being between 2,000 and 3,000 tons. In the year 1900 the average tonnage of steamers afloat was about 1,900 tons, and the gross tonnage of the steamers built during that year averaged about 3,000 tons, very many of the steamers being between 3,000 and 4,000 tons.

By the year 1905 the average tonnage afloat of cargo steamers had increased to about 2,250 tons, and the average tonnage of cargo-steamers built that year was about 3,300 tons. At the present time the great bulk of cargo-steamers range between 3,000 and 4,500 tons. There is not just now a marked tendency to build cargo steamers of a larger size, but rather to build a greater proportion of the total number of sizes between 4,000 and 4,500 tons, these being apparently the tonnages found most suitable for the general ocean carrying trade.

Much larger cargo steamers are, of course, built, but they are, for the most part, associated with certain well-known passenger lines, chiefly in the Atlantic trade. The ordinary cargo steamer of to-day ranges in length from about 300 ft. to 380 ft.

For vessels which have to go seeking, which is the case with the average cargo steamer, it is most important that their draught of water should not exclude them from any port where cargoes may be obtained. It is this question, then, of draught of water which limits the dimensions of such vessels; for draught fixes depth, and, within a small range, depth limits length.

A SUCCESSFUL PIECE OF HYDRAULIC GRADING.

Though hydraulic grading is by no means a new thing, it is thought worth while, on account of its remarkably successful termination, to describe some work of this kind which was done in connection with river improvements on the Mississippi, about 40 miles below St. Louis. At this place a hurdle had been built out into the stream and in order to form a revetment at its end, a bank 16 ft. high and practically vertical had to be reduced for a distance of 300 ft. to a slope of 2½ to 1. Bad weather and the scarcity of labor compelled the devising of some more expeditious method of grading the bank than the usual shoveling. It was therefore decided to make the cut by use of a stream of water forced through a small nozzle pipe; that is, by hydraulic grading.

In previous work of this kind, trouble has generally been found in the formation of gullies in the bank which had to be filled by hand at great loss of time and money and in addition left the surface in poor condition for riprapping with rock. To avoid trouble of this sort, 280 cu. yds. of spalls were brought to the site on barges and shoveled against the vertical bank at the water's edge, forming a berm about two feet wide on top and rising one foot above the water. These stones once in place, the grading was begun from the top of the bank, as shown in Fig. 1, by cutting down a small width to the desired grade and with this as a guide extending the grading as far as required. The berm of stones prevented the formation of pockets and large gullies and held the deposit of washed material.

The apparatus used to force the stream of water consisted of a No. 12 Hooker force pump, 16-in. stroke, making between 50 and 60 strokes per minute and placed on a pile-driver moored to the bank. This pump was connected to a 2½-in. rubber hose with a home-made gaspipe nozzle 2½ ft. long, with a 1¼-in. vent. By this apparatus 3,444 cu. yds. were moved, with a surfacing by hand of only 44 cu. yds. The total cost was 2½ cts. per yard.

Fig. 1. Reducing a 16-ft. Bank by Hydraulic Power.

Fig. 2. Finished Revetment, Mississippi River Improvement.

After the grading was completed riprapping was begun at the ridge of stone and carried to the top bank. Below a 4-ft. stage (St. Louis gage), the bank was protected by a brush mattress 100 ft. wide, with one-half a cord of brush per lineal foot of length. Connection was made between the bank revetment and the mattress edge by throwing rock into the water from a barge and ascertaining the proper amount of stone with a sounding rod. The finished work is shown in Fig. 2.

This work was in charge of Mr. F. Y. Parker, U. S. Assistant Engineer, to whom we are indebted for the information and photographs herewith presented.

SHIPPING A MAST 138 FT. LONG BY RAIL was recently accomplished by the Great Western Ry., of England. The mast was of steel, 3 ft. in diameter at the base, and weighed 14 tons. It had to be transported from Liverpool to Plymouth. Seven four-wheeled flat cars were used, the mast resting on bolsters on the second and fifth cars, the bolsters being about 85 ft. apart. The mast was transported by a special train, traffic being stopped on the second track at some points where sharp curves existed. At the sharp curves entering the dock-yard traveling Gantry cranes were employed to ease the load as the train passed around the curves. The same train also carried three masts of 74 ft. to 78 ft. in length, which were loaded on five flat cars.

SURVEY WORK FOR A TWO-MILE VIADUCT, KEY WEST EXTENSION OF THE FLORIDA EAST COAST RY.

By GEORGE P. CARVER,* C. E.

In the construction of the principal viaduct on the Key West Extension† of the Florida East Coast Ry., it was necessary to locate points and give lines and grades for piling and concrete-forms for nearly 200 piers. A description of the methods employed for this may be of interest to engineers generally, especially as these methods proved effectual and produced no delays in the work of construction.

This viaduct is known as the Long Key-Conch Key Viaduct, as it connects two of the Florida keys of these names. It is about two miles in length. The maximum depth of water is about 16 ft. The bottom is of lime rock, generally quite soft, overlaid by a layer of 2 to 6 ft. of sand. All the piers are founded on piles, which were in most cases driven without much difficulty. At some of the pier locations, however, it was impossible to obtain any penetration whatever, with a 20-ft. pine pile under an 8,500-lb. steam hammer. Here recourse was had to a steel shaft or punch, about 8 ins. in diameter and 20 ft. long, which was driven to a depth of four or five feet into the rock and then withdrawn, the pile being driven into the hole made by the punch and a further penetration of two or three feet obtained. All piles were driven to refusal under ten blows.

There are two abutments and 179 piers in the viaduct. Thirty piles per pier were driven, on the average, of which ten were in two rows outside of the pier for supporting bents for arch centers. In each pier, points for six piles were given by instrument, and the other piles were located by measurement from these, thus requiring no measurement over 5 ft. except in checking distances between piers. Thus, about 1,100 piles scattered along a length of two miles were located by instrumental work.

The writer was appointed Division Engineer in charge of the work in June, 1906, and early in that month took up his residence on a large quarter boat with a corps of assistants. Several days after mooring in a sheltered position on the inside of the Long Key near the southerly end, the first instalment of plant was towed to the site of the work, comprising a pile-driver and a barge of 20-ft. piling. Previous to arriving on the work the writer had given very little thought to the method of giving points. It was thus necessary to devise a desirable and practical method in the interval of two or three days subsequent to the arrival of the pile-driver, which was ready for duty without delay.

*Bank Bldg., Beverly, Mass.

†An illustrated article on this new line, with a map of the route and detailed drawings of the reinforced-concrete arch viaduct work, was printed in our issue of Oct. 19, 1905, pp. 407 to 409.

The center line of the road ran back on Long Key in the middle of a 100-ft. cleared right-of-way for about one mile to a P. T. and was approximately defined by stakes every 300 or 400 ft. In the other direction the line was defined very roughly by three or four piles driven at intervals of 1,000 to 2,000 ft. between the Keys, which were about three miles apart, and extended across Conch Key, which is perhaps 500 ft. long, the location of the line being lost at this point. Continuing, the line ran across an opening for about three miles beyond Conch Key to a P. C. on Grassy Key. The tangent was therefore about seven miles in length and the view between the P. T. and P. C. was obstructed somewhat by the height of the growth on Conch Key, which, however, was later cleared, allowing a clear view from each end of tangent.

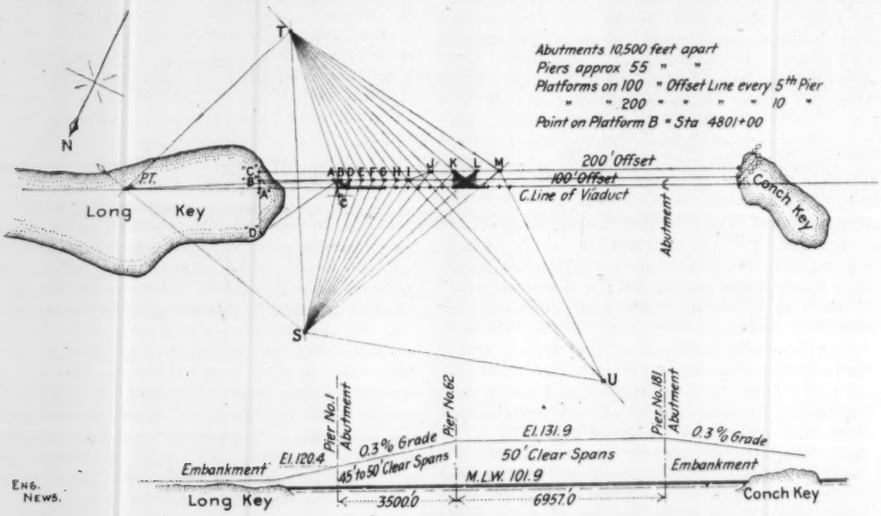


FIG. 1. SKETCH MAP OF SITE OF LONG KEY-CONCH KEY VIADUCT; KEY WEST EXTENSION OF FLORIDA EAST COAST RY.

The writer was appointed Division Engineer in charge of the work in June, 1906, and early in that month took up his residence on a large quarter boat with a corps of assistants. Several days after mooring in a sheltered position on the inside of the Long Key near the southerly end, the first instalment of plant was towed to the site of the work, comprising a pile-driver and a barge of 20-ft. piling. Previous to arriving on the work the writer had given very little thought to the method of giving points. It was thus necessary to devise a desirable and practical method in the interval of two or three days subsequent to the arrival of the pile-driver, which was ready for duty without delay.

On P. T. and P. C. a 2 × 3-ft. diamond-shaped canvas target nailed to a 2 × 4-in. stick 12 ft. long was set up in correct position by aid of a transit, and was secured against wind by wire guys made fast to the top of the 2 × 4 in. and to substantial stakes driven in the ground. On definitely fixing these two points so as to be in transit sight from any point on the tangent, a transit was set on the southerly end of Long Key near the shore and worked into line by reversing the telescope and turning 180° [illegible] the reversals, using the P. C. six miles [illegible] on Grassy Key as a foresight, gave points [illegible] oximately 1 in. either side of the center [illegible] of P. T. target. A point near the instrum[illegible] was then set, by driving a 4 × 4-in. stak[illegible] eral feet into the ground and setting a tack [illegible] on the line. This point is designated as [illegible] on the accompanying sketch map Fig. 1.

From this center-line point, the st[illegible] of which was known, two offset points were [illegible] tab-lished towards the east or ocean side [illegible] the line, respectively 100 and 200 ft. out fr[illegible] point "A" (points "B" and "C," Fig. 1). Th[illegible] points served to establish offset lines paralle[illegible] the center line, from which offset lines th[illegible] tual locating of piers was carried out. A [illegible] lar group of center-line and offset points [illegible] set on the nearest shore of Conch Key. [illegible] each point a permanent sight mark was set [illegible] To distinguish the center line, it was ma[illegible] d by three 2 × 3-ft. diamond-shaped targets, v[illegible] ally one above another, on a 2 × 4-in. stic[illegible] 12 ft. high, well guyed. The 100-ft. offset li[illegible] was marked by a single-target sight, and th[illegible] 200-ft line by a two-target sight, all similarly con-structed and set up.

For the purpose of locating station points along the offset lines, to check direct measurement, four triangulation points were also established. Of these one, "D," is located at the southwesterly corner of Long Key, on the same transverse line as points "A," "B" and "C." Three others, S, T and U, are on pile platforms in the open water, being so chosen as to give good intersections with the center and offset lines in the work of locating the viaduct piers.

The site of the north or Long Key abutment of the viaduct is about 1,000 ft. out from the southerly end of Long Key, in about 10 ft. of water. The piledriving began with this abutment. For the purpose of locating this foundation, two platforms were erected, with a floor about 4 ft. above high tide, on the 100-ft. offset line and in such a position that the station of the springing line and the stations of those piles in the abutment at right angles to the center line could be established on the forward one of the two platforms, and the prolongation of the center line of the wing-wall piles, where it intersected the 100-ft. offset line, would fall on the other platform. Fig. 2 shows the relative location of the abutment and the platforms. In locating piles, instruments were set upon two platforms (A and B), and the piles at intersection of rows and the end piles in wing walls were located by intersection of transit lines or by angle and distance. All remaining piles were located by measurement from fixed points on other previously driven piles. The piles were driven in the order of numbering in Fig. 2 to allow movement of the pile-driver, a barge 24 × 60 ft. with 50-ft. leads.

The location of the springing line of the abutment on platform B, Sta. 4,801, was approximately established by measuring out from offset stake

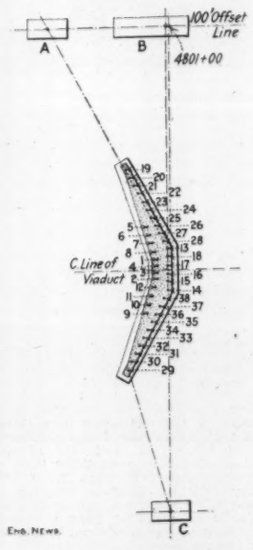


Fig. 2. Plan of North Abutment Piling and Survey Platforms A, B and C, Long Key-Conch Key Viaduct.

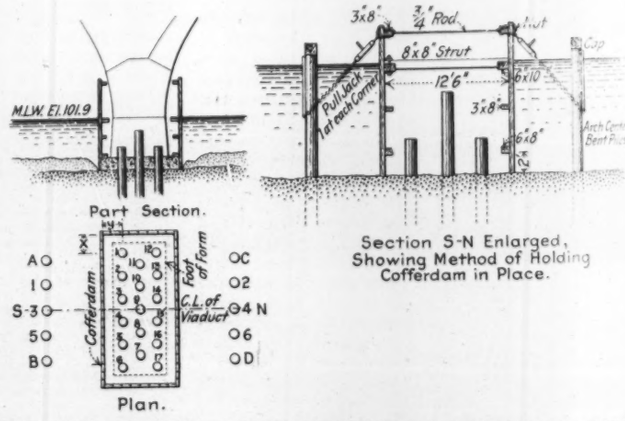


FIG. 3. PLAN AND SECTION OF INTERMEDIATE PIER FOUNDATION AND COFFERDAM, LONG KEY-CONCH KEY VIADUCT.

"B[illegible]n Long Key. Later the point was more accurately established by triangulation from stake [illegible] turning the computed angle from line [illegible] to intersect the 100-ft. offset line on [illegible]801.

roadbed over the first 62 arches of the [illegible]rly end of the viaduct, a length of 3,500 [illegible] on a grade of 0.3% upward to the south, [illegible]g with a height of 19.5 ft. above M. L. W. at the abutment and ending with a height of [illegible] at top of grade, Pier 62. From the latter [illegible] southward a level grade is maintained to the far abutment. All of the 180 spans have a [illegible]lar intrados of radius 25 ft., the rise [illegible] 14.7 ft. at the first arch and 25 ft. on the level grade (the arches on the level portion being semi-circles). The springing line is at M. L. W. in all spans. The spans on the grade thus decrease gradually from 50 ft. to 45 ft. at the north end, so that the spacing of pier-centers increases as the grade rises.

The piers on the level grade were designed to be 8 ft. 6 ins. wide and 19 ft. 8 ins. long at M. L. W. (El. 101.9), except that every fifth pier was 12 ft. wide to act as an abutment, allowing the completion of the arch rings in sets of five. On the grade the width and length of the piers at M. L. W. were made proportional to the height of the coping above M. L. W., but in order to avoid having to construct a different sized pier form for each pier, the widths and lengths at M. L. W. were made up in sets of ten with the same dimensions, using the mean width and length of the set.

Platforms were constructed on the 100-ft. offset line opposite the center of each wide pier location, and the transverse pier center line located approximately by measurement from the platform. The exact location in all cases was obtained by cutting the offset line from one of the triangulation points S, T or U. These platforms are typically shown in Fig. 4, a view of Platform C, an auxiliary in the location of the north abutment. A single pile was driven opposite each pier, on the 100-ft. offset line between the platforms. These piles were used for measuring between platforms, and later for mooring purposes and pile driver lines. On account of the strong current these piles proved necessary for this purpose, which led to the placing of two rows of mooring pile clusters on the other side of the viaduct, approximately 200 and 400 ft. distant from the center line.

In order to save time and minimize error in the instrumental work for locating the piling of the piers intermediate between platforms, a large-scale plan similar to Fig. 1 was made, showing all piles and platforms and all angles from each platform to the piles in the adjoining sets of piers (to be located from that platform). These angles were copied into notebooks in tabular form, making a separate notebook for each platform for the use of the instrument man. Thus it was necessary only that the instrument man should have the proper notebook, lettered the same as that platform, and knowing merely the number of the pier and number of the pile to be driven he could read the angle from his notebook, turn this angle, give line, and, by intersection with the line given simultaneously from the next platform, establish the exact location of the pile in question. An engineering inspector stationed on the driver held a rod in position between the leads, and the driver was shifted until the rod was at the intersection of the instrument lines; then the spuds were dropped, the steel punch swung into the leads, driven, and withdrawn, and finally the pine pile driven. The pile-driver, handled by several lines run ahead, astern and from each

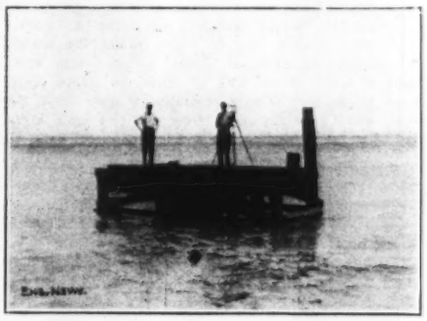


Fig. 4. One of the Survey Platforms.

quarter, could with very little loss of time be got into proper position for driving.

Fig. 3 shows the location of the foundation piles in a regular pier and of the adjacent arch-center bent piles. These were generally driven in the following order, referring to the numbering shown in Fig. 3; South bent, A, B. 5, 3, 1; Foundation, 1, 6, 5, 4, 3, 2, 11, 10, 9, 8, 7, 17, 16, 15, 14, 13, 12; North bent, C, D, 6, 4, 2. Of these, generally the first two piles in each of the two arch-center bents and the first two pier-foundation piles were located by transit intersections, and tacks were set on these piles, to denote the exact survey point; the remaining piles were located from these by measurement. The inspector stationed on the pile-driver was provided with a sketch of the pier showing the spacing of the piles each way. The inspector kept a record of length of pile, depth of water, depth of sand and rock penetrated, number of blows, and penetration under last blow.

After several platforms had been constructed on the 100-ft. offset line opposite each fifth pier as shown on sketch, the writer decided there would be several advantages gained by working from the 200-ft. offset line and placing the platforms at every tenth pier, in this way saving one-half in the number of platforms constructed while obtaining angles but little sharper than those in the previous arrangement. This new method also allowed a greater working width between cofferdams of piers and survey platforms for the supply steamer, barges, etc. The method was put into effect by running off on a diagonal line from platform I the computed distance until it intersected the 200-ft. line at the tenth pier, where platform J was built; from this point on the platforms were built on the 200-ft. line, ten piers or about 550 ft. apart. In actual use this method of working proved to possess the expected advantages as compared with working from the 100-ft. line.

After the foundation piles of a pier were driven and cut off, and the concreting was ready to begin, a cofferdam was set in proper position from the points on anchorage piles 1 and 6 in each pier by using distances x and y, Fig. 3, being held in positon by pull jacks secured to the arch-center bent piles (Fig. 5). When the cofferdam was jacked securely to the bottom, the sand was jetted into suspension and pumped until the rock was clean and the edges of cofferdam rested on the rock. A seal of 2 ft. of concrete was then placed and allowed to set for about a week, at which time the cofferdam was pumped dry and pier forms and reinforcement were properly set and secured, and the pier concrete was placed.

In giving line for a pier form, the center line of viaduct was run by an instrument set on a platform erected on the center line back of the north abutment, using the center line mark on Conch Key as a foresight, and this line was then marked with nails on each side of the cofferdam. The transverse center line of pier was then placed on ends of cofferdam by measurement from transverse center line on the last completed pier, being originally located by measurement from the abutment (Sta. 4,801).

On the establishment of these points the four sides of the pier form are assembled in the cofferdam in exact location, the top of form being set to M. L. W. (El. 101.9) by levels run out from a benchmark on shore.

During the pouring of the pier a 2 × 2 in. wooden plug is set in the concrete on the top surface of the pier at the intersection of the center lines, and after the concrete has hardened the exact center is located on the plug and a nail driven. This point is then used as an instrument station and the center line carried forward from it, always using the center-line target on Conch Key as foresight.

The stations of each pier and all its dimensions and elevations were prepared in the form of tables and blue printed in books of handy size to carry in the pocket on the work. This book of tables also contained spans, rises, elevations and other desirable data, for the use of the engineer on the work. A record of this kind proved virtually an absolute necessity, as the first 62 piers and arches are all different in length, width, span, rise, etc., on account of the grade in the roadbed as already noted.

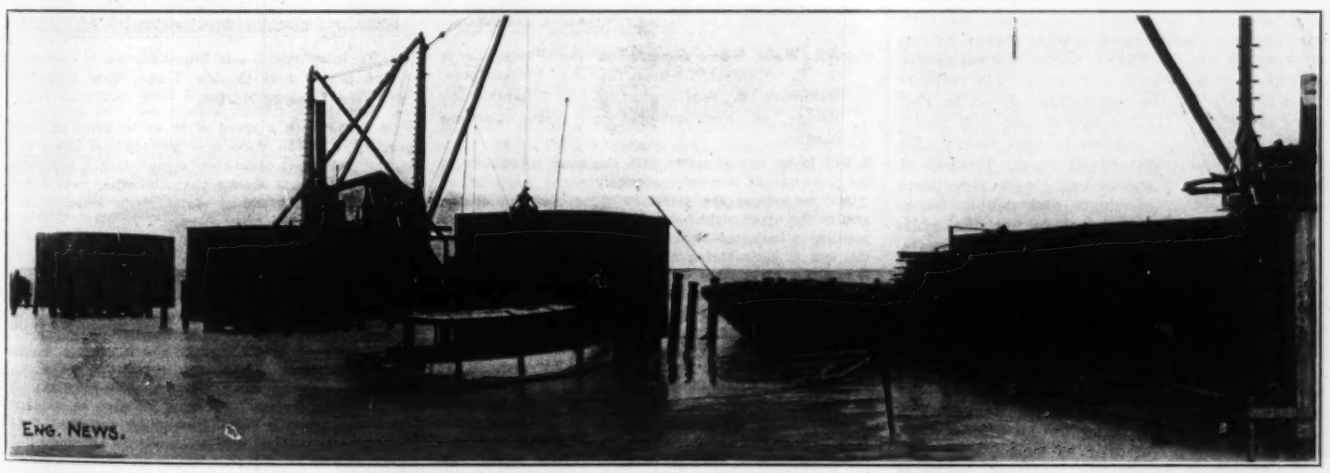


FIG. 5. NORTH ABUTMENT AND PIERS 2, 3 AND 4, LONG KEY-CONCH KEY VIADUCT.

(Cofferdams ready for sinking.)

A NEW SYSTEM OF BLOCK SIGNALING ON THE PENNSYLVANIA R. R.

A new system of signaling which involves some novel features and some distinct departures from ordinary practice is now in experimental service on the Pennsylvania R. R. It was developed by a special committee of the railway company's officers, and is stated to have proved very satisfactory. The special features may be enumerated as follows: 1. The semaphore arms move upward instead of downward from the horizontal position ("stop") to the inclined ("caution") and vertical ("clear") positions. 2. Two semaphore arms and two lights are used for every indication, except those governing low-speed movements; for these latter an additional small arm and dim light are provided. 3. The signals are used to give two kinds of indications when at the "stop" position: (A) Stop, wait a specified time, and then proceed. (B) Stop and remain until the signal indicates "proceed." The former is distinguished by a longer upper arm and the two lights offset from a vertical line (as in Fig 1). The latter is distinguished by having the arms of equal length and the lights disposed in a vertical line (as in Fig. 2). 4. At interlocking plants, the signals indicate for speed rather than for routes.

This new system has been in use for about four months between Philadelphia (49th St.) and Elwyn, Pa., on the Central Division of the Philadelphia, Baltimore & Washington Ry. The distance is about 12 miles, all double track, with the exception of about 4,000 ft. at Elwyn, this being the end of the double track portion of the line. There are about 17 blocks, 3,500 ft. to 4,500 ft. long, with 156 signals. The blocks include crossovers, sidings, the junction of a branch, and the connection of the single and double track sections; a great variety of conditions has therefore to be covered by the signal equipment. During the morning rush hours, there are ten trains in a little over two hours, and during the evening there are nine trains in a little less than two hours, the average time between trains in both cases being 13 minutes. During December there were three failures of signals: one due to a broken wire and another to a weak battery, while the cause of the third was not discovered.

At each signal, the two arms for each track are 6 ft. apart vertically. In most cases they are carried on steel posts set at the side of the track, the base of the post forming the case for the battery and mechanism. At one point, the post is carried on a bracket projecting from the side of a cut. In some cases, where the width of right-of-way is limited, the signals for both tracks are mounted upon a steel signal bridge, as shown in Fig. 1. This is north of Swarthmore and the view is looking northward. The respective indications of the two signals shown in Fig. 1 are as follows: (1) For southbound (left hand) track; Proceed with caution to next signal. (2) For northbound (right hand) track; Proceed at full speed. Fig. 2 shows two single pipe posts at the connection of single and double track, north of Elwyn. Each of these has the additional arm and light for low-speed movements, already noted. The signal in the foreground indicates "Proceed at moderate speed." The one beyond the interlocking tower (with all three arms horizontal) indicates "Stop and wait until signal gives a clear indication."

It will be noticed that in Fig. 1 the two lamps on each post are set on opposite sides of the post, making the upper arm appear longer than the lower arm and showing the two lights 2 ft. apart horizontally (c. to c. of lenses) and 6 ft. vertically. This, as already explained, indicates that this signal when at the "stop" position means: Stop, wait the prescribed time and then proceed. In Fig. 2 both the main (upper) lamps are on the same side of the post, making the arms appear of equal length and showing both lights in a vertical line. This indicates that the signal when at the "stop" position means: "Stop until signal changes to proceed." It is stated that by day the different positions of lamps and length of arms are easily apparent, while at night the difference is very marked. On the other hand, considerable doubt has been expressed as to the ease of distinguishing the two classes of signals under varying conditions of service and weather, and also doubt as to the advisability of giving so many different indications.

The following is an abstract of a descriptive statement issued by the railway company in regard to this new system of signaling, which is to be used by both the Pennsylvania and the Baltimore & Ohio railways at the new terminal at Washington, D. C. In our editorial columns we have commented upon this and other developments in railway signal practice.

Two arms and two lights will be displayed on every high signal. With existing signal arrangements the number of arms and lights is variable and depends upon track conditions, so that there may be from one to five on a post. If any arm is broken or a light extinguished an engineman would probably not notice it; while if there were always two, he would notice the slightest derangement of either of them. A small arm with a light of lower power will, at times, be placed further down on the post or on a separate low post. This, however, will be so far away from the two main signals and of so much smaller size and less powerful light, that it will in no way interfere with the main indications of the two-arm and two-light principle.

Fig. 1. New Block Signals on the Pennsylvania R. R. (Central Division of the Philadelphia, Baltimore & Washington R. R.); Signals on Bridge at Swarthmore, Pa. (View Looking North).

Day indications are given by three positions of the arm in the upper right hand quadrant, and at night each position is indicated by a different colored light. When the arm is horizontal a red light is displayed; when it is raised to an angle of 45° a green light is displayed; and when it is still further raised to a vertical position, a white light is displayed. Should the system be generally adopted, however, the colors would probably be red for "stop," yellow for "caution" and green for "clear," thus avoiding the white light altogether. Raising the arm above the horizontal has a distinct advantage over the usual practice of lowering it below the horizontal. Accumulations of ice, sleet, etc., on the arm tend to move it downward; with the new arrangement this would indicate caution or stop, while with the old arrangement the downward movement would indicate either "caution" or "proceed at speed."

Three classes of signals or signal indications are employed, as follows, the first two alone governing train movements: (A) "Stop and Stay" signals, at which a train, if stopped, must stay until the signal is changed to a position allowing it to proceed. This class includes interlocking, train-order, controlled manual, manual-controlled, and telegraph-block signals. They may be distinguised by the fact that the lights are vertically over one another and the arms appear the same length. (B) "Stop, wait and proceed" signals. A train stopped by signal may proceed after waiting a specified time, even though the signal has not changed and still indicates "stop." This class includes automatic signals (and incidentally distant signals when the latter are used as independent indications). They may be distinguished by the fact that the lower arm and light are not directly under the upper arm and light, but located toward the left, so that the lower arm appears about 2 ft. shorter than the upper one, and the lower light shows on the left hand side of the post, while the upper one shows on the right hand side. This staggered relation of the two signals is very noticeable both in the daytime and at night. (C) Signals which give information only and do not authorize or restrict train movements; these include switch indicators (both home and distant), flag-station, water-tank, and stop and slow signals. They are indicated by horizontal lights and special designs for day indications. These signals are all low and do not interfere with the two-signal principle used on the high poles.

The signals designate the speed of the trains rather than the routes, at points where interlocking systems are used. (A) The top arm governs the high speed track, provided no crossover movement is included in the route. It indicates proceed at highest speed permissible, modified (of course) by curves or any arbitrary order limiting the speed. (B) The second arm governs medium speed movements, and refers to a divergence from the high-speed routes, such as an easy cross-

Fig. 2. Interlocking and Block Signals at Connection of Single and Double Track Near Elwyn, Pa. (View Looking North).

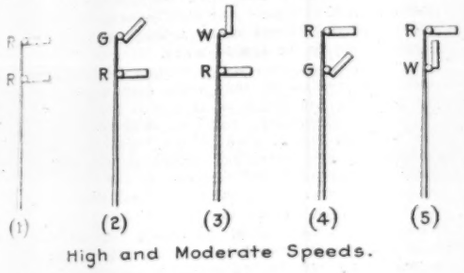
over upon which a speed of 40 or 50 miles an hour is proper. (C) The third arm governs low speed movements; over short crossovers, against traffic, into sidings, etc. This arm is shorter than the other two; it has a short range light and is placed much lower down the post than the two main signals.

The interpretation of the signals is as follows: (1) Red light and horizontal arm, "Stop." (2) Green light (or yellow, as above) and arm at 45°; "Proceed under control to the next signal, which is at 'Stop'." (3) White light (or preferably green) and arm vertical, "Clear, proceed at speed; next signal is at 'clear' or 'caution'."

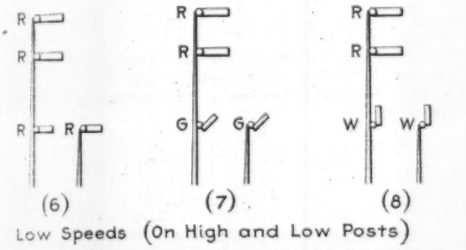
All interlocking signal arms remain normally in the horizontal position and at night show a red light. The arms are moved one at a time, so that an engineman could not pass any signal post unless the signal for his particular movement was at "caution" or "clear." The other signals on the post would all be at "stop." On signal posts where no high-speed route exists, the top arm is fixed in the horizontal position and the light is always red. At signal posts where no crossovers or moderate speed routes exist, the second arm is fixed in the horizontal position and the light is always red. The only case when the top and second signals would both be out of horizontal position at the same time is on an automatic signal post where the lower arm would act as a distant signal for a medium-speed route controlled by an interlocking tower ahead. The diagrams in Fig. 3 show clearly the signal movements and their meanings.

Two interlocking plants are included in this installation. These are mechanical, but all signals are electro-pneumatic. Compressed air at 90 lbs. per sq.

in and electricity at 500 volts are furnished from a centrally located plant. The air is transmitted through a 2-in. main and the electricity by a No. 6 copper wire. Electricity for operating the track circuits and signals is taken from storage batteries located at the various signals. The batteries are charged in series from the power supply, eight hours at a time, four nights a week. The batteries have chloride accumulators, each signal pole being supplied with two cells. One cell is used to operate the 16-ohm. signal cylinder magnets and also to feed the track circuit in the rear through a 1-ohm resistance in connection with the rails. The other



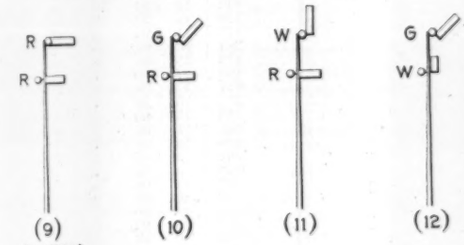
High and Moderate Speeds.



Low Speeds (On High and Low Posts)

Class A: "Stop and Stay" Signals for Interlocking Plants and Train Orders.

1. Stop and stay till signal indicates proceed.
2. Proceed with caution to next signal, on high-speed track.
3. Proceed at high-speed, on high-speed track.
4. Proceed with caution to next signal, on moderate-speed track.
5. Proceed at moderate speed, on moderate-speed track.
6. Stop and stay till signal indicates proceed.
7. Proceed with caution, on low-speed track.
8. Proceed at low-speed, on low-speed track.



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Class B: 'Stop, Wait a Time, Proceed"; for Automatic Signals (and for Distant Signals when used for Independent Indications).

9. Stop, and proceed after waiting prescribed time.
10. Proceed to next signal, prepared to stop.
11. Proceed at speed; next high-speed signal is at "caution" or "clear."
12. Proceed at moderate speed; next moderate-speed signal is at "caution" or "clear."

Fig. 3. Diagram of Signal Indications on the New Block Signaling System of the Pennsylvania R. R.
R = Red Light; G = Green Light; W = White Light.

cell is in circuit ready for charging. The system of circuits is known as the "polarized wireless," the only wires used being those for the charging line, approach indicators, locks for interlockings, and indication locks of the signals.

The signal cylinders are tandem and the arms are pulled to the "clear" position by a 3/16-in. rod instead of being pushed to that position by a ¾-in. pipe or 1-in. rod. This new construction saves considerable power. The relays are 5-ohm, universal, neutral polar, and the pole changers are pneumatic. It has developed that an ordinary mechanical pole changer would probably be as well suited to the work. All switches are equipped with rotary circuit controllers which shunt the track through two No. 6 wires when switches are open. All boot-leg wires are No. 6, plugged through the web of the rail with channel pins and running direct to battery, relay or pole changer without splices.

All sidings are equipped with pipe-connected derails, a number of them being of the Hayes type, operated from the main track switch levers. Both ends of the main line crossovers are operated through a switch and lock movement from one ground lever placed in the middle of the crossover tracks. This makes it impossible for careless trainmen to close the switches and clear the signals with a light engine standing on the crossover, and avoiding the use of special circuits to protect this danger point. At first, trainmen unfamiliar with the device used too much force on this lever, and connections were sprung or switch timbers moved. This trouble has practically ended, but in future installations it will be preferable to use this lever merely to lock the points for main track, operating the points from ordinary switchstands. This will make flying switches possible, while insuring that the switches must both be locked before the signals will clear, the circuit closer being operated by the lock itself instead of by the switch.

All interlocking home signals are power operated, semi-automatic, controlled through stick indicators so arranged that they go to the "stop" position on the passage of train, and cannot be operated again until the train has left the circuit, and the operator has restored his lever to the normal position and again reversed it. Approach indicators and approach locking are provided, taking effect one block in the rear of the distant signal, and so arranged that if the home lever latch has been raised it cannot be put down to release the machine locking until a period of two minutes has elapsed. The circuits are so arranged that if a portion of the train is left on the approach circuit the locking automatically releases when the engine enters the home signal circuit. Thus no hand or time release is required for ordinary trailing drill movements; but if a second train enters the section, the approach locking will become effective as soon as the home signal is cleared for it to proceed.

The slow hand-release (so called) is really a time release, operated pneumatically and so arranged that it is out of control of the operator. The first application of this ingenious device was made at Morton. Special lamps and brackets were provided, as with those in ordinary use the lost motion between the lamp socket and bracket were sufficient to allow the lens in many cases to angle so much to the side as to prevent its focusing properly along the track.

The treatment of the signal at Elwyn (the last one of the system, and on the single track portion) was one of the debatable points. This being the commencement of the block system and track-circuit controlled, three courses were open. The lower arm is the distant for the next signal beyond, and is consequently two-position. If treated as an automatic block signal, the top arm (with track occupied) would also show "stop." Thus a stop signal would be displayed with no warning distant signal in the rear, which violates the principle of advance information for every stop signal. If treated as is the custom at the beginning of an automatic installation on the Pennsylvania R. R., namely, as a distant signal simply, and not indicating the condition of the track, it obviously should not have the lower arm at "stop" and the top arm normally at "caution," as this is the aspect of the other signals when the next signal is at "stop" and the track is clear. Hence the top arm was fixed at "caution" and the lower arm moves only from "caution" to "clear." This can only be cleared when the track is unoccupied, so that this latter aspect does not conflict with the other signals, and in the normal indication two arms at 45° form a different aspect from any other signal displayed.

It is still an open question whether or not this should be made a "stop and proceed" signal. The arguments in favor are that then the "caution" position would always mean track clear and next signal at "stop" on every signal; and the "stop" indication would never be displayed unless the track were occupied when a "stop" is required. The argument against is the lack of a distant signal, in turn, for this signal.

Another point has developed in working out the details of the signaling for the new terminal at Washington, where this system is to be installed jointly by the Baltimore & Ohio R. R. and the Pennsylvania R. R. With all interlocking signals semi-automatic, as in the installation above described, it is impossible to attach cars or switch engines to trains, or to close trains in, except under hand signals. The same difficulty exists on all roads in automatic limits, when the interlocking home signals are semi-automatic. It is now proposed to make the low-speed arm, semi-automatic, from "caution" to "clear" only; and to so arrange the locking and circuits that it may be displayed at "caution" for any route, including the high-speed routes, if the latter are blocked by cars within the interlocking limits.

In other words, if a high-speed route is clear and next signal at "clear," the top arm will clear. If the track is clear and the next signal at "stop," it will assume the "caution" position. If the track is occupied, the top arm will indicate "stop," but the third or low-speed arm may be shown at "caution." This would combine the safety of the semi-automatic feature for high-speed movements, and the elasticity now attained where (as at outlying interlockings) the signals are not semi-automatic, and hand signals are the exception rather than the rule.

OPERATION OF THE NEW HAVEN WATER CO.'S FILTER PLANT.*

By CHAS. A. FERRY,† M. Am. Soc. C. E.

Two years ago I presented a paper to this society describing the new filtration plant of the New Haven Water Co., at Whitneyville, at that time under construction. Since that time the works have been completed, and for the past ten months have been supplying an average of about 8,500,000 gals. per day of filtered water to the city of New Haven.

Upon the completion of the structure preparations were made for securing the sand and gravel for the filtering material. The company owned extensive beds of sand and gravel about a mile and a half from the plant, which a mechanical analysis showed to be suitable for the purpose. Plans were made, and the necessary machinery secured for washing and separating the materials into the various sizes required. We soon found, however, that theory and practice are widely at variance where sand screening and washing are concerned, and we were obliged to do considerable experimenting before our apparatus could be made to work to our satisfaction.

As finally constructed, our plant consisted of a hopper into which the material was dumped as it was carted from the bank. From this it was elevated about 15 ft. by a chain and bucket elevator and dumped into the screens. These consisted of three hexagonal screens, arranged concentrically on a shaft, varying in length from 7 ft. for the outer to 13 ft. 10 ins. in length for the inner screen. These screens were held in position, 4 ins. apart, by means of four spiders fastened to the shaft and carrying, by means of lock nuts on the arms of the spiders, 2½ × 1¼-in. strips of wood, to which the wire netting was fastened. The outer, or sand screen, was of 1-10-in., the second of ¼-in., and the third ½-in. mesh. Crushed trap rock was used for the two coarser layers of stone.

The screens were set on a slope of 1 in 8. The mixed material was dumped at the upper end and, as the screens revolved, the material gradually worked its way to the lower end, except the sand which passed through its screen, where it was delivered into chutes which conveyed it to separate storage bins.

Over the top of the screens was placed a 3-in. water pipe, perforated with ⅛-in. holes every ½-in., which delivered a shower of water onto the screens and converted the sand into a semi-fluid condition and prevented the screens from clogging. To successfully screen sand by machinery, it must be thoroughly dry, or else mixed with a sufficient amount of water to make it run freely; in any intermediate condition the screens will choke up and no sand will pass through. This is a trick which we learned only after considerable experimenting.

After passing through the screen the sand was received into a box, where it received its first washing. It was expected that one washing would be sufficient to remove all of the finer material, but we found that it was practically impossible to remove all of the particles below the 1-100-in. limit.

The sand, instead of being single crystals, was largely composed of conglomerates, exceedingly fine particles cemented together with oxide of iron. These rough particles retained the silt, which no amount of washing would entirely remove. It is probable, however, that the sand as delivered to the beds is actually better than the mechanical analysis would show, as a certain amount of fine material is produced by the attrition of the sand grains against one another and against the wires in passing through the sieves. It was found that by passing the sand twice through the sieves the amount of material passing the finest sieve was about doubled.

From the receiving box the sand was carried by a 1½-in. pipe into the washing machine, which consisted of a box 12 ft. long, 32 ins. wide and 26 ins. deep at the inlet, and 32 ins. deep at the outlet end. On the bottom of the box was laid, its entire length, three lines of 4-in. pipe, connected by a 5-in. main to the water tank located on top of the sand storage bins. These pipes were perforated every 2½ ins., on the under side, with ⅜-in. holes for the first half of the pipe and ½-in. holes for the remainder. The sand was admitted at the shallow end of the box and moved gradually to the deeper end, where it was discharged from the hopper; in the meantime being separated from the finer particles, which were carried by the current of water to the surface, where it overflowed into a drain which carried it away.

From the hopper the sand was raised by an elevator to the storage bin. This was 12 ft. long, 8 ft. wide and held about 25 cu. yds. It was raised a sufficient height above the ground to permit of the sand being delivered by chutes into the carts. The bottom of the bin was made water tight, on a slant of 1 in 6. On the bottom

*A paper read before the Connecticut Society of Engineers, February, 1907.

†With A. B. Hill, Consulting Engineer, New Haven, Conn.

was nailed ¼-in. square battens, on which were tacked a layer of ¼-in. wire netting, and on this another course of ⅛-in. mesh. This provided free drainage for the sand pile and quickly removed all water not held by capillary attraction. Along the lower edge of the bin was suspended a trough which conducted the water to the drain.

A direct-acting pump with 5-in. suction and 4-in. discharge supplied the 750-gal. tank, located on the top of the bins, with water; and a 15 HP. engine furnished power for running the screens and elevators.

Three men were required to run the plant. About 75 cu. yds. of material could be screened and washed per day, and the total cost of putting the prepared sand and gravel into the bins, not including the cost of the plant, was about 37 cts. per cu. yd.

The sand did not furnish a sufficient amount of the finest grade of gravel, or grits, for our requirements and an effort was made to supply the deficiency from Long Island, but the dealers there would not furnish us with the grits unless we purchased sand also, and as the company was anxious to get the filters into working order as soon as possible, a contract was made with the captain of a steam barge to furnish us with such amount of sand and gravel as we might need.

This sand was brought from the White Star Sand Co., of Northport, L. I., and was of much better quality than that obtained from our local beds. It consisted entirely of crystals, was very uniform in size, was remarkably free from particles finer than 1-100-in., some samples having none whatever and scarcely any having more than .2%, while samples of the local sand which tested as low as .5% were rare, although, as previously stated, a considerable portion of this was probably caused by the breaking up of some of the conglomerates in passing through the sieves. Our specifications for sand were: Material which will pass a screen with 0.1-in. mesh and will not contain more than 0.5% of material which will pass a screen with 0.01-in. mesh. It shall have an effective size of not less than 0.25 mm. nor more than 0.35 mm.; and shall have a coefficient of uniformity of not more than 2½.

The first sand which we got out, and the first shipments from Long Island, were nearly alike as to size and uniformity, and it was put together indiscriminately in the beds, but, subsequently, the local sand ran finer while the white sand ran coarser, and it was then placed in separate beds. The local sand varied from about 0.24 to 0.27 mm. for effective size while the Long Island sand ran from about 0.34 to 0.36 mm. Both sands appear to give about the same result as regards the quality of the effluent; but the fine sand beds will not run quite so long without cleaning as those filled with the coarser material.

The depth of the sand in the different beds varies from 2 ft. to 3 ft. 8 ins., in order to secure regular rotation of the beds; the bed with the least depth being left idle as a receptacle for washed sand from the other beds.

The water is maintained at a constant depth on the beds by means of a balanced float valve placed on the 12-inch inlet pipe.

Two or three engineers who had had experience with valves of this type gave us the cheering assurance that this portion of our apparatus would give us more trouble than all of the remainder put together, and when we made our first test their doleful prophecy seemed destined to be fulfilled, for when the water rose to within about 2 ins. of the established level, the valve began to pound at the rate of a blow every two or three seconds with a force which threatened to break every joint in the pipe line.

These valves were cone-shaped, and the back of one valve presenting a larger surface to the current of water than the face of its mate caused the valve to become unbalanced; consequently the pounding.

The pattern of the valve was changed, substituting a piston valve for the cone-shaped ones, the face of the valve being tapered just sufficiently to permit of the piston entering the cylinder without catching. Since this change was made we have had no difficulty with them; they work without noise, and keep the surface of the water at the desired level.

The filters were placed in commission March 20, 1906, and have been in continuous service since. The first bed was cleaned July 20, and the eleventh bed 27 days later; the shortest run for any bed being 116 days and the longest 143 days; an average of 130 days. On the second run, which included the warmer months, the shortest period was 66 days and the longest 75 days; an average of 72 days.

The highest rate at which the filters have ever been run is 4,500,000 gals. per acre per day.

As the applied water is nearly free from suspended matter, the sand does not clog to so great a depth as in some other slow sand filters; the material removed in cleaning being only about ½-in. in depth. After a bed has been cleaned it is refilled with water and allowed to stand for 12 hours. The filtered water is then turned into the sewer and allowed to run until the turbidity is reduced to one, usually about 6 hours, when it is turned into the clear water well.

The apparatus used in cleaning the sand consists of three separate pieces, with necessary hose and pipe connections—an ejector, a sand washer and a sand receiver; shown by Figs. 1 to 3.

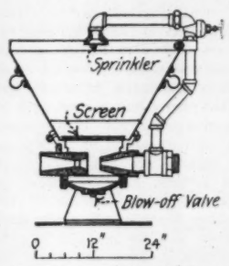

Fig. 1. Sand Ejector Used at the Filters of the New Haven Water Co.

The ejector consists of an iron hopper with a pipe nozzle, and a throatpiece so arranged at the bottom of the hopper that a stream of water from the nozzle enters the throatpiece and carries with it the sand in the hopper, on the same principle that a steam injector feeds water into a boiler. The nozzle is connected by a hose to a 6-in. high pressure water main, and the throatpiece is connected in like manner to a line of 3-in. cast-iron pipe, which in turn is connected by a hose to the inlet pipe of the washing machine.

A sprinkler at the top of the hopper sprays the sand and converts it into a semi-fluid condition, preventing it from arching in the hopper; and a blow-off valve in the bottom provides a ready means for emptying the hopper in case of any derangement of the apparatus.

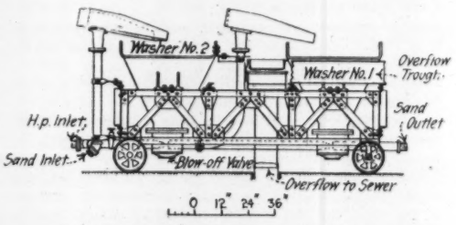

Fig. 2. Sand Washer, Filter Plant of the New Haven Water Co.

The washing machine consists simply of two ejectors, connected together in a frame, for convenience of handling, and provided with overflow troughs for removing the dirty water and conveying it to the sewer.

The sand receiver is a large tank of boiler iron divided into two compartments by a partition about 1 ft. from one end, and with three slide valves in the bottom for the removal of the sand. The narrow section of the receiver is connected, at the bottom, with a 6-in. spiral riveted pipe, which discharges into the inlet chamber of the filter bed, which for the time being is converted into an outlet chamber through its connection with the sewer.

The sand is shoveled into small piles with a broad, flat, iron shovel and is then wheeled in barrows to the ejector, which is stationed near the center of the bed. It is then shoveled into the ejector and from thence is carried by the stream of water to the first hopper of the washing machine; from here it is carried, in the same manner, to the second hopper and from thence, in the same way, to the sand receiver; the dirty water overflowing the top of the hoppers into the collecting troughs and from thence passing to the sewer.

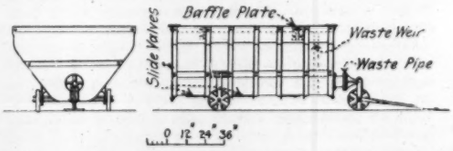

Fig. 3. Receiver for Washed Sand, Filter Plant of the New Haven Water Co.

The sand settles to the bottom of the receiver and the water overflows the partition and discharges into the sewer through the spiral riveted pipe before mentioned. The sand receiver is suspended from the roof of the filter, the roof being strengthened and provided with eye bolts at three places in each bed for that purpose.

The entire work of moving the sand from the time it is shoveled into the ejector in one bed until it is taken from the receiver in another bed is done by water, no manual labor being required except that one man is employed in keeping the side collecting troughs of the washing machine free from sand, a small amount of which is carried over by the water.

Ten men are usually employed in cleaning. The setting up and taking down of the apparatus, the cleaning of the bed and resurfacing of the sand, occupies about one day for each bed.

The water pressure, at present, is only 40 [illegible] is only about one-half the pressure used in [illegible] plants, and is too low for the rapid handl[illegible] sand. A new pump has been purchased b[illegible] installed, which will increase the pressure to [illegible]

Daily bacteriological tests are made of [illegible] samples being taken of the applied wate[illegible] effluent from each bed, from the main lead[illegible] clear water well and from the main leading [illegible] pump to the reservoir.

The accompanying table shows the averag[illegible] results of the daily tests since the first of [illegible] (1906). No B. coli have ever been found in [illegible] samples of the filtered water although they [illegible] quently found in the applied water.

The platinum chloride test is used in deter[illegible] color. The average turbidity varies from 0 t[illegible] per 1,000,000; practically all of this is remo[illegible]

A curious phenomenon has been observed [illegible] tion with the loss of head of the water [illegible] through the sand, which has puzzled us, and [illegible] theory yet advanced has explained to our sa[illegible] When the beds are clean, the loss of head is [illegible] 0.2-ft. and little change is noted for two [illegible] weeks; then it increases at a gradually accele[illegible] until the loss is about 5½ ft., when the filter stops passing water and the bed has to be cleaned.

On two occasions, when the loss of head has reached about 2½ ft., the loss of head has suddenly dropped back to 0.2-ft. and has then steadily risen to the 5½-ft. limit.

I wish here to acknowledge my indebtedness to Mr. Walter J. Connor, bacteriologist at the filter, for the assistance he has rendered in the preparation of this paper.

BACTERIAL AND COLOR REDUCTIONS—NEW HAVEN WATER CO.'S FILTER PLANT.

1906 Week ending		Bacteria—Per cc. Applied water.	Filtered water.	Per cent. removed.	Color— Applied water.	Filtered water.	Per cent. removed.
May 5,	1906.....	131	18	86			
" 12,	"	191	17	91			
" 19,	"	108	14	90			
" 26,	"	70	8	90			
June 2,	"	658	20	97			
" 9,	"	252	30	90			
" 16,	"	175	32	81			
" 23,	"	240	30	90	17	8	53
" 30,	"	112	13	80	15	8	46
July 7,	"	154	27	82	12	7	42
" 14,	"	142	13	91	10	6	40
" 21,	"	132	12	91	8	5	37
" 28,	"	175	11	94	6	4	33
Aug. 4,	"	183	16	91	5	3	40
" 11,	"	175	15	91	8	4	50
" 18,	"	133	27	80	7	3	57
" 25,	"	117	12	90	8	5	38
Sept. 1,	"	221	15	93	7	5	30
" 8,	"	156	15	90	8	5	37
" 15,	"	195	11	95	7	4	43
" 22,	"	160	16	91	7	4	43
" 29,	"	201	15	93	7	3	55
Oct. 6,	"	113	9	92	7	4	43
" 13,	"	117	13	90	8	5	37
" 20,	"	160	12	93	9	4	55
" 27,	"	2140	15	99	12	7	42
Nov. 3,	"	394	15	97	20	16	20
" 10,	"	170	16	94	25	20	20
" 17,	"	216	8	96	18	12	33
" 24,	"	633	9	98	12	10	20
Dec. 1,	"	366	8	98	12	8	33
" 8,	"	295	5	98	12	8	33
" 15,	"	303	8	97	12	9	25
" 22,	"	443	6	99	10	8	20
" 29,	"	480	5	99	9	7	22

THE DETROIT RIVER TUNNEL OF THE MICHIGAN Central Ry. was commenced last autumn, but work has so far been confined almost exclusively to the approach tunnel sections. A little dredging was done last year, but stopped early in December. It was found necessary to build a somewhat different type of dredge, and this, as well as a strike which the dredging contractors now have on hand, has delayed operations this spring. They are expected to start again about the middle of May. There has been little of special interest in the approach tunnel work, but a number of lineal feet of drifts have been driven, and space provided for concreting portions of both the center and side walls. This work has been done without the use of compressed air, the material being supported by timbering; and it is the intention of the contractors to complete the entire work without the use of compressed air. The material through which the work is being driven is clay, and has been giving some trouble on account of its tendency to flow, so that the contractors found it necessary to make some changes from the method originally contemplated for the approach tunnels. For this reason they are not making rapid progress, as it is the intention to use shields and these have been ordered. The Butler Bros. & Hoff Co., of New York, are the contractors, and Mr. W. S. Kinnear, M. Am. Soc. C. E., is chief engineer. The original plans for the construction of this tunnel were described in our issue of Feb. 15, 1906.

MAINTENANCE OF ASPHALT PAVEMENTS.*

By S. WHINERY,† M. Am. Soc. C. E.

That beyond question that the serviceability of asphalt sheet pavements has been seriously impaired and their reputation as desirable pavements for city streets greatly prejudiced through the neglect and failure of cities and contractors to keep them in a proper or even a tolerable state of repair.

The causes which have led to this state of affairs are not difficult to discover and locate. Nearly all asphalt pavements are constructed under contracts which require the contractor to guarantee and maintain the pavement for a stipulated term of years. The practice of requiring such a guaranty originated in the early history of this pavement, when its merits and demerits were little known, and when the knowledge of its proper construction was confined largely to those engaged in promoting and constructing it. Under these conditions the requirement of a service guaranty was a wise precaution and fully justified. But these conditions no longer prevail to any considerable extent. Experience has demonstrated the character and capacity of the pavement, and most municipal engineers are able to specify how the work should be done and to supervise it intelligently; or, if not, the necessary expert assistance is readily procurable. The only theory upon which the requirement of a guaranty can be now based is that if the contractor be compelled to maintain his work for a considerable period of years he will be more likely, for his own protection, to use the best materials and to perform his work in the best manner. In other words, it is an attempt to make the contractor responsible to himself, as well as to the municipality, for imperfect or improper work, by compelling him to suffer the consequences of his own remissness. As a theory, no serious objection could be raised to such a requirement, provided it could be practically enforced, and if it did not logically involve the corollary that if the contractor is to be held responsible for results he must not be hampered in exercising his judgment as to the use of materials and methods that will, in his opinion, produce the result guaranteed.

It is not intended to here discuss at length the subject of time guarantees on municipal public work, except in so far as it relates directly to the subject in hand. The writer has gone into the matter at length in a chapter of his book, "Municipal Public Works."

As applied to pavement contracts, the practical objections to time guaranties arise largely from the difficulty of drawing the line clearly between the things which the contractor may and those which he may not reasonably be required to guarantee. This is so because of the difficulty of clearly distinguishing, in practice, between defects due to improper work or to the use of unsuitable materials, and those due to the natural and inevitable wear and tear of travel, and to other destructive agencies over which the contractor can have no control, and for the results of which, therefore, he can not be logically or reasonably held responsible.

To avoid this difficulty, guaranty clauses are usually so drawn that they amount to a requirement to maintain the pavement for the stated period, regardless of whether repairs become necessary as the result of the contractor's unsatisfactory work or as the result of ordinary wear and tear. The only exceptions to this general rule are in the case of repairs that become necessary by cutting into the pavements or by palpable accidents, and even these are sometimes included. Too often guaranty clauses are so indefinite and ambiguous that it is difficult to determine exactly what the contractor is expected to do. This leads to constant differences of opinion between the municipality and the contractor as to what repairs the latter should make at his own expense, resulting frequently, if not usually, in long delays in making such repairs.

But even where no such disputes arise the contractor is generally negligent and procrastinating in making repairs that are indisputably required under his guaranty. His self-interest impels him to expend as little money as possible upon the maintenance of the pavement.

Under the various conditions that tend to depress contract prices he is likely to underestimate, and in some cases to disregard entirely, the cost of maintenance under the guaranty. Even if he is able to foresee all the conditions to which the street will be subjected during the guaranty period, and if his knowledge and experience enable him to correctly estimate the cost of maintenance, he is likely to presume upon the well known laxity of municipal officers in the enforcement of the terms of the guaranty. Later, he is likely to find that he cannot, without losing money, keep the pavement in such repair as the public has a right to demand, and it is human nature that he should try to evade the requirements, and to get out with as little expenditure as possible. In the pursuance of this policy he is likely to cavil over the reasonableness of demands made upon him, to avoid making repairs wherever possible and to do the work he may be compelled to do as cheaply as possible. He will try to defer making any repairs until a sufficient quantity of such work accumulates to enable him to do it in the most economical manner.

It would be manifestly unfair and untrue to charge that all contractors thus try to evade the requirements of the guaranty, but it can be said that so many of them do so that it may be regarded as the prevailing practice.

That the municipalities have contributed to this state of affairs cannot be denied. Where previous experience has shown that contractors are not likely to be forced to live up strictly to the terms of such guaranties, they can hardly be blamed for presuming that the same policy will be continued. They are likely to assume that prevailing custom has at least as much weight in the interpretation of a specification as its literal wording. Furthermore, they are likely to take advantage of the fact, well known to them, that the city is, under prevailing conditions, practically unable to enforce the penalties prescribed in the contract. Proceedings against bondsmen are tedious and often practically abortive. The instances where cities have been able to recover from defaulting contractors upon their bonds are quite rare. The alternative plan, to withhold from the contractor a sufficient sum in cash to safely cover possible default, is objectionable because it is so burdensome as to drive small contractors out of the business and to seriously cripple even the strongest. For these reasons it is almost sure to result in higher prices being demanded for the work. The common provision that in case the contractor fails to make repairs promptly and properly the city may proceed to do the work or to have it done by others and to charge the cost to the contractor, looks promising, but in this particular branch of municipal work is generally ineffective. Often no other contractor in the city has the necessary equipment to do the work, and even where there are two or more entirely independent asphalt paving plants their owners are not disposed to meddle with each other's affairs. It is impossible for the city itself to do the work without the necessary plant and materials, and very few cities are now provided with these. It thus results that however carefully the contract and specifications may have been prepared, and however urgently the contractor may be pressed to comply with them, he is able to snap his fingers and say, "What are you going to do about it?"

The same, or rather worse, conditions prevail with regard to repairing the pavements on streets upon which the contractors' guaranty has expired. If it is attempted to provide for the making of such repairs by contract, a condition of monopoly often exists which will enable the contractors prepared to do such work to practically dictate prices and terms; and the same difficulties are encountered in trying to enforce repair contracts as were experienced under the original guaranty contracts. The municipality is again helpless, and however urgently it may act, the streets continue in a condition of bad repair.

It cannot be denied that the condition of asphalt pavements in most cities is unsatisfactory, while in many it is deplorable and is rapidly becoming intolerable. To attribute this condition to inherent inferiority of this kind of pavement, as many people do, is wholly unwarranted. Everything considered, a well constructed and properly maintained asphalt pavement is not inferior to any other kind of pavement now in use. At the same time it must be conceded that an asphalt pavement usually requires attention and repairs at an earlier period in its life than most of the other pavements in common use, and it is probable, though not yet certain, that the total cost of maintenance during its useful life is also somewhat greater. It is certain that it requires more frequent and careful attention during its life to keep it in a proper state of repair than do stone or brick pavements. It is often the case that high-grade articles or structures require more careful and skillful attention than the cruder varieties of the same class. It will certainly not be claimed that the value of a pavement may be measured by the amount of neglect and abuse it will endure.

One not unimportant result of the requirement of long time guaranties on asphalt pavement has been that the municipal authorities, depending upon the contractors to make all necessary repairs, have not concerned themselves much with the problem. Consequently, when the guaranties have expired, the cities have too often found themselves unprepared and helpless in the matter, and compelled to make such further arrangements with the contractors as the latter are disposed to exact.

The state of affairs here outlined cannot much longer be tolerated. Some remedy for the present inexcusable condition of the pavements must be provided and some system devised that will prevent the recurrence of such conditions in the future. The problem thus presented to municipal officers is a large and difficult one; all the more difficult because it is comparatively new.

The prime condition of its successful solution must be that the city shall be in a position to control the situation. This means that it must be able effectually to compel the contractor to comply with the obligations he has assumed, or to exact an adequate penalty.

As the first important step in this direction, the city must avoid, in the contract and specifications, requirements that are indefinite and ambiguous and under which the contractor's duties cannot be clearly determined and enforced. We have seen that the long period guaranty involves inherent conditions which, under the above stipulation, it is necessary to avoid. It should therefore be omitted from all future contracts. The art of constructing asphalt pavements is now so well understood that it is entirely possible to frame and administer specifications that will insure the production of a first class pavement, and the conditions that originally dictated these guaranties therefore no longer exist. The attempt thus to make the contractor responsible for the character of the work he does has not, in practice, been found effectual; moreover, our present knowledge of how the work should be done and the practicability of thorough inspection and supervision renders the resort to such an expedient largely unnecessary. But if a time guaranty is still thought advisable the period may be made so comparatively short that questions of faulty construction shall not be confused with those of maintenance. Barring accidental and unusual injuries, maintenance questions ought not to arise within a period of two years after the completion of the construction work, while palpable construction faults should be revealed within that time. The guaranty period should not, therefore, exceed two, or, at the most, three years. Maintenance after that period should be provided by the city. Under such construction contracts the whole question of maintenance may

*A number of articles, also by Mr. Whinery, appeared in our columns during 1903-1904, under the general title, "Some Observations on Street Pavements."

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be dealt with as a separate problem, as both theory and experience indicates that it should be. The consideration of this problem is the main object of this article, but it seemed desirable to review briefly the conditions under which it now presents itself to a large number of municipal governments.

It is probable that, in the end, it will be found most satisfactory and economical for cities to have the great majority of their pavements maintained under the contract system. Under the conditions of municipal government that now exist and which will probably continue, it is likely to be the case that a contractor can do his work equally as well, and at a cost, including a reasonable profit, which will be lower than the actual cost if done by the city direct. Assuming this to be true, it is desirable for this as well as other reasons that the contract system shall be adopted in the main, *provided always* that the city shall have the power and the means to compel the contractor to comply squarely with the terms of his contract.

How may this important provision be secured? It is now well recognized that in this work of constructing and repairing asphalt pavements effective competition cannot be depended upon. Even if no organic combination among the contractors should exist, the special character of the work and the expensive equipment required is likely to confine competition within very narrow limits, so narrow that in most cities not more than two or three contractors will be prepared to undertake such work, and these are not likely to antagonize each other's interests, while in many of the smaller cities but a single contractor will have the plant necessary to construct and repair asphalt pavements. The only certain way to secure the benefits of competition is for the cities to be in a position to assume the role of competitor whenever occasion seems to require it. To be in a position thus to compete with contractors a city must have the necessary equipment and organization to undertake the work. The writer is convinced that the possession by the city of an equipment for repairing asphalt pavements is the key to the situation. Having such a plant the city will be in a position, if not to make all its repairs, to effectually enforce the clause found in most paving contracts, authorizing the city, in case of the contractor's default, to itself enter upon the work and make the necessary repairs, charging the cost to the contractor.

In the majority of cases the contractor, if he knew the city was thus prepared to enforce its demands, would be careful not to give occasion for it to do so. Thus, the simple possession of such an equipment by the city, even if it were never operated, would enable it to control the situation, and for this reason alone would prove a good investment.

The usual arguments against municipal ownership of public utilities obviously would not apply to such a plant. The motive here would not be the argument that the city could do its work direct more economically than it could have the same work done by contract, but that it would be the most effectual means of compelling contractors to comply with the terms of their contracts. At the same time a sufficient amount of repair work could be reserved from contract to keep the plant fairly occupied and to thus meet interest charges and the expense of operation. This would be true with regard to existing guaranty contracts, as well as repair contracts.

Such a municipal plant should be designed especially for the making of street repairs, though it should be available for original construction work on a comparatively small scale, if occasion should arise to employ it in that way. It is not yet sufficiently well recognized that an equipment designed for asphalt pavement construction on a large scale is not, usually, most suitable and economical for repair work. One of the reasons for the present tardiness of contractors in making repairs is that their plants, being designed primarily for original construction work, which must be turned out on a large scale, are not suitable for economically turning out material on the small scale usually required for repair work. It is, therefore, most economical for the contractor to allow his repair work to accumulate until the quantity will justify the starting up, at very considerable expense, of his plant. The ordinary repair work in most cities will require material for only from 100 to 500 sq. yds. of pavement per day, while the regular construction plants are designed to turn out material for from 1,500 to 2,000 sq. yds. per day. The ideal repair plant should not only be designed to turn out economically the smaller quantities, but should also contemplate the making of small repairs promptly, without starting up the main plant, and should be also designed to work over and use good old material taken up from the street. These features will be more particularly referred to later in this article.

An equipment designed along these lines need not be an expensive affair. The standard asphalt paving plant costs from $15,000 to $30,000, while the expenditure of half these sums would provide an adequate repair equipment for most cities of medium size. In cities where the area of asphalt pavement is very large, it would usually be better in every way to build two or more such repair plants, judiciously located, than to spend their cost upon a single large plant.

One of the serious mistakes made by the few cities which have erected asphalt paving plants of their own has been the adoption of large and expensive equipment, designed along the same lines as the construction plants now in use, without reference to the special requisites for a plant intended primarily for repair work. In the present state of general knowledge on this subject, no city should attempt to erect a municipal paving plant without the advice of some one who is familiar with the subject from large actual experience.

The essential features of such a municipal plant may be briefly outlined:

(1) It should have a capacity to turn out asphalt paving mixture in the best manner, sufficient to lay or relay from 500 to 750 sq. yds. of pavement per day. Larger quantities will seldom be needed for repair work, and for such construction work as the city is likely to want to undertake the larger quantity named is sufficient.

(2) But if repairs are promptly made on the streets whenever required, the quantity of material used daily will be much smaller than even the lower figure named, and it is very expensive to start up and keep the whole plant in operation to turn out such small quantities each day. Nor is it necessary. The mixed material may, by proper treatment, be stored, and such quantities as are required may be simply reheated each day at comparatively little expense.

The writer speaks from experience, having employed this method several years since in a number of cities. When at any time the construction plant was turning out more material than was then required on the street, the surplus hot paving mixture was spread out in thin layers on a plank floor to become cold. It was then stored in comparatively thin layers in small buildings designed for the purpose. If small repairs became necessary at times when the plant was not in operation, this cold stored material was taken to the street and reheated in portable heaters to the proper temperature, and the repairs made with it at comparatively small expense. This system is capable of large and successful application, the chief requisite now being suitable and effective apparatus for reheating on the street, which is not difficult to design. It is obvious that this cold material could be stored in suitable quantities at various points throughout a city, from which the repair forces could readily obtain it when wanted. Small or incipient holes, and even quite large cuts, could thus be repaired with great promptness.

(3) The idea seems to prevail with city authorities that surface material cut out of the street is inferior, and that its reworking and use for repairs should not be permitted. Nothing could be more erroneous. Experience has demonstrated that such reworked material, if intelligently handled, is at least as good as, and not infrequently superior to, the original material when first laid.

Even if this statement is not fully accepted, it must be conceded that such reworked material is good enough for making repairs to comparatively old pavements whose life is not expected to extend over many more years. Experience has shown that such material can be reworked and used at a much lower cost than new material can be supplied. To cart away to the city dump good, bright material cut out of the streets is, therefore, the most inexcusable waste. Whatever reasons may be urged for prohibiting its use by contractors (and those reasons are usually based upon ignorance of the real value of the material), there can be no good reason why a city engaged in making its own repairs should not preserve and utilize this old material, thereby saving annually a large sum of money. All that is required to handle it successfully is suitable appliances and a knowledge of how to manipulate it properly at the least expense. This old material may be stored at convenient points and reworked on the street as required, thus saving the expense of long hauls to and from the permanent plant for treatment. A suitable equipment for working over such material, both at the permanent plant and on the street, should therefore be a part of every municipal repair plant.

(4) The practice of mending old garments with new cloth of the original quality has been insisted upon in the repair of asphalt pavements. In the life of every asphalt (or other) pavement there comes a time when, while it is more economical to repair than to resurface the whole street, repairs can only be expected to remain in use for at most a few years. True economy suggests that no more money be spent in such repairs than is absolutely necessary. It is manifestly absurd to put into a pavement which must be resurfaced in three or four years patches that are good for a dozen or more years' service, if cheaper adequate repairs are possible. Consequently, it may often be desirable to substitute for the standard pavement mixture something which, while it will serve the designed purpose, will be much cheaper. Some of these possible substitutes are low-grade asphalts or even coal tar pitch, or bituminous concrete in some of its many forms. A municipal repair equipment should be designed with reference to the preparation and use of such substitutes where it is found that money can be saved thereby.

(5) To state the case as briefly as possible, when a city decides to provide itself with a repair plant, a careful study should be made of what the city is likely to require for the most economical maintenance of its streets, and the whole equipment should be intelligently designed to accomplish the purpose in the most economical manner.

As the conditions in one city may differ materially from those in another, a plant which would prove best in one may prove unsatisfactory in another, and it might be very unwise to adopt in one city plans which have given satisfactory results in another. It is the old and familiar question, met everywhere by engineers, of wisely selecting the best means to secure the desired end.

Assuming that the city should find it advisable, for any reason, to make all or a part of its own street repairs, some practical points may be considered. In the first place contracts made, whether for construction, with guaranty provisions requiring the contractor to maintain the pavement, or for maintenance alone, should always provide (as many of them now do) that in the event of the contractor's default, the city shall be authorized to make the necessary repairs, charging the cost of them to the defaulting contractor, and in the case of contracts for repairs, crediting him with the value of the work at his contract price. This amounts, in effect, to charging him with any excess in the cost of the work above his contract price. The charge made should include, in addition to the cost of labor, materials and supervision, a reasonable allowance for interest, depreciation and repair on equipment; and it is entirely fair that it should include the usual contractor's profit on similar work. It might, of course, occur that the whole cost to the city would be less than the

contractor's price, but it would obviously be inadvisable to give him the benefit of a credit in such cases.

As surety for the payment of such charges against the contractor the city should retain out of funds that would otherwise be due him a sum in cash which it may think sufficient for the purpose. This sum, being intended to cover only the possible difference between actual cost and contract price, would not be so large as to embarrass the contractor. The usual bond security should not be relied upon or accepted in cases of this character.

Coming now to the actual work of making repairs, it will, of course, be necessary for the city to have at hand the skilled labor and superintendence required to do the work in the best manner, but, for ordinary repair work, such a force need be neither very large nor very expensive.

For determining the proper mixtures, and for general supervision and advice, it will always be found advantageous and profitable to employ for consultation a competent expert, particularly in inaugurating the work.

The character and extent of the organization will, of course, depend largely upon the quantity of work likely to be done, and will vary in the case of each individual city. When not required for this particular work, the men engaged may usualy be profitably employed upon other municipal work. Where the city elects to do its own repairing, instead of having it done by contract, there will usually be, if there is a considerable area of asphalt pavement, enough work to keep a small force pretty constantly employed. Provision should be made for a complete record of the work done and its cost.

The actual cost of maintenance will depend almost as much upon the promptness with which necessary repairs are made as upon economical handling of the work in general. When, for instance, a small depression appears in the pavement, it may be surface-patched at very small expense. If unattended to, the impact of wheels falling into the depression will soon form a hole in the pavement. As the entire circumference of this small hole is subjected to abrasion by travel, it enlarges rapidly, the area increasing roughly as the square of the diameter, and where a few cents would have covered the cost of repairs at first, as many dollars may be called for in a comparatively short time on a street of heavy travel. Vigilance and prompt attention is the keynote to successful and economical maintenance of asphalt pavements.

With the proper equipment and organization prompt repairs will always be practicable. Having a supply of cold pavement mixture stored at convenient points, and the appliances required to reheat and handle this material on the street where wanted, it will be a comparatively simple and inexpensive matter to repair any defect as soon as it appears, whether in the summer or the winter season.

To go into details of manipulation and management would unduly extend this article, and is not necessary. Under intelligent and skillful supervision these details will receive the proper attention as a matter of course.

There seems to be no good reason why every city having any considerable area of asphalt pavement should not thus put itself in a position to control this important matter of pavement repair. The initial cost of the necessary equipment would be comparatively small. All the necessary supplies can be bought in the open market, and the skilled labor and such expert advice as is necessary can be readily procured. The possession of such an equipment would not only enable the city to control existing repair contracts. It would also exert a wholesome influence upon the bidders for new contracts, whether for repair or for original construction. Knowing that the city was not at their mercy bidders would hardly attempt to exact exorbitant prices, when otherwise they might do so. Even in new construction work the city would be able to offer effective competition and regulate prices, since it could undertake and, if necessary, execute a very considerable amount of work. A plant capable of turning out material for 500 sq. yds. per day, in addition to that required for repairs, would enable a city to construct from 40,000 to 50,000 sq. yds. of new pavement in a single season.

AN EARLY AMERICAN PIN-CONNECTED TRUSS BRIDGE.

We reproduce herewith a half-tone view showing a portion of one of the earliest pin-connected truss bridges built in the United States.

This bridge was constructed in 1858-9 for the Lehigh Valley Railroad Co. by Mr. John W. Murphy, under the direction of Mr. Robert H. Sayre, then Superintendent of the road. It is one of a number of somewhat similar bridges which Mr. Murphy constructed about this time, and is described in Mr. Theodore Cooper's celebrated paper on "American Railroad Bridges" as "the first truss bridge, as far as the author has been able to discover, which was pin-connected throughout." The length of the bridge was about 165 ft., composed of cast-iron compression members, diagonals of wrought-iron bars with welded loop eyes, and bottom chords of wrought-iron full-link bars, as shown by the photograph. It differed from the ordinary Whipple-Murphy bridge of that time in that pins of wrought-iron, unturned, were substituted for the usual cast trunnions on the post feet. The floor system was of timber construction.

It was first erected to span the Morris Canal at Phillipsburg, N. J. In 1869 the bridge was taken down at Phillipsburg and re-erected as the center span of a bridge crossing the North Branch of the Susquehanna River, on the main line of the Lehigh Valley Railroad at Towanda, Pa., where it was in service until 1879.

In 1879 the span was again taken down and remodeled by substituting wrought-iron end and vertical posts for the cast-iron posts, and wrought-iron floor-beams and stringers for the timber floor system. It was then erected to span Cayuta Creek (formerly known as Shepard's Creek), on a connecting link between the Lehigh Valley R. R. and the Lehigh & New York R. R. (formerly Southern Central R. R.), at Sayre, Pa., where it remained in service until the fall of 1906, when it was removed and assigned to the scrap heap. The original cast-iron top chords and the full link bottom chord bars were in the structure until removed last fall.

We are indebted to Mr. F. E. Schall, M. Am. Soc. C. E., Bridge Engineer of the Lehigh Valley R. R., for the photograph and information here presented.

FIG. 1. FLOOR-BEAMS AND LOWER CHORD OF THE FIRST ALL-PIN CONNECTED TRUSS BRIDGE BUILT IN AMERICA.

(Erected in 1859 by John W. Murphy for the Lehigh Valley R. R. Co., at Phillipsburg, N. J. The wrought-iron floor-beams shown in the view replaced the original timber floor-beams in 1879.)

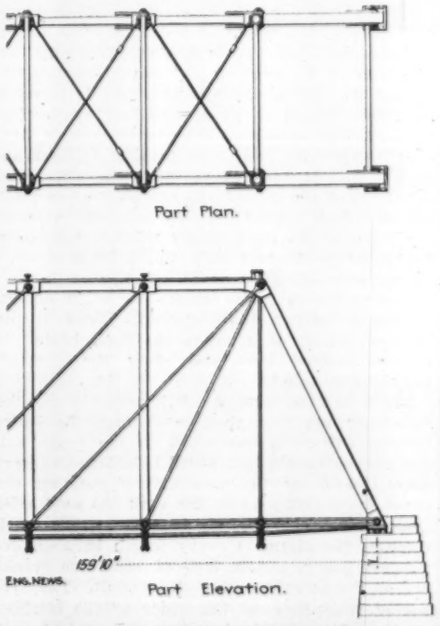

FIG. 2. VERTICAL SECTION, PART ELEVATION AND PLAN OF PIN-CONNECTED TRUSS BRIDGE BUILT IN 1859.

THE NEW JERSEY COAST RESORTS are to be linked by a trolley line from Sandy Hook to Cape May. At present in most instances the only feasible way of getting from one of these resorts to another is a 60 to 80-mile trip back to Philadelphia or Trenton and then by another road back to the coast. There are now numerous short-line trolleys connecting individual resorts, and the present project proposes to fill the gaps between them thus making a continuous line. The greater part of the road will be equipped with the third-rail system, and it is believed that when the service is perfected the trip from Cape May to Sandy Hook will be possible in from four to five hours.

THE GRINDING OF RAILS OF STREET RAILWAYS in England, in order to maintain them in surface and to remove corrugations due to wear, was described in our issue of April 11. This latter trouble has been very serious at Leeds, and at the shops of the Leeds municipal street railways a rail-grinding machine has been built, utilizing the frame of the steam truck of an old steam motor car. It has a 25-HP. electric motor for propelling the machine, and a 10-HP. motor for the traversing, grinding, drilling and sawing operations. The traversing speed is 21.6 ins. per minute, and the corundum grinding wheels run at a peripheral speed of about 5,200 ft. per minute when new, and 3,300 ft. when worn; these wheels are 20 ins. diameter when new, and are allowed to wear to 12½ ins. before being renewed. The tracks are laid with 7-in. grooved girder rails, and behind the wheel which grinds off the rail head is another narrower wheel which cuts out the bottom of the groove so as to maintain sufficient depth of flangeway. The shafts for driving the rail saws and drills are run at 225 revolutions. The entire machine is enclosed in a cab or housing reaching to within a few inches of the ground, and resembles an old style dummy engine.

NOTES ON EXPANSION AND CONTRACTION OF CONCRETE STRUCTURES.

By A. C. LEWERENZ,* M. Am. Soc. C. E.

The following observations as to the effect of expansion and contraction on concrete and reinforced concrete structures at the U. S. Navy Yard, Puget Sound, Washington, are considered to be of interest to the engineering profession.

All of the structures described have been exposed to temperatures covering about the maximum range in this locality, or from 8° to 95° F., according to official reports. The temperature in the sun was of course greater, but was not ascertained. These structures have recently been examined, immediately following the coldest weather of the year, when expansion joints or temperature cracks would naturally show the maximum opening.

Fig. 1 shows a solid concrete quay wall built four years ago. Earth filling behind it was completed during the first year. The movements of the tides on the face doubtless maintain the temperature of the wall at nearly that of the water. The top and the upper part of the face would, therefore, alone be subject to rapid changes of temperature. The wall is in excellent condition. All of the expansion joints appear to be active, opening as much as 3/16-in. There are many fine cracks across the top of the wall, none of them extending more than 6 ins. down the face, below the cast-iron nosing. The cracks are not sufficiently wide to admit of inserting even a thin knife-blade, and are probably not more than 2 or 3 ins. deep through the wall. They do not appear on the back of the wall. They occur at intervals of 5 or 6 ft., and very frequently come at the end of one of the pieces of cast-iron nosing, or at one of the end anchorages of the nosing sections. The wall is founded on hardpan, so that there are no settlement cracks.

Fig. 2 shows a reinforced concrete wall completed last summer, which has, therefore, passed through a summer and a winter. It is much more exposed to temperature changes than Fig. 1, as the filling in behind it has not yet reached the wall, and it is therefore subject to the alternate action of water and air below high water line, and to all changes of temperature above high water line, on both sides of the thin face and coping slabs. The face, being toward the south, receives the direct rays of the sun. This wall, over 1,200 ft. in length, was built entirely without expansion joints, it being considered that the reinforcement would hold the concrete from creeping sufficiently at any one place to cause much cracking. Careful examination shows that a crack has occurred on an average of about once every 75 ft., running across the top and down the face. These cracks are very fine, and especially on the lower part of the face can scarcely be detected without the closest inspection, even in cold weather. They cannot be found on the back of the face slab, and are apparently, therefore, not cracks through the slab. They do not appear to follow any special law; in some cases they occur at places where sections of the wall were joined in building, but do not follow the stepping of the joints; in other cases they come opposite a buttress on the back. They are, it is believed, not to be considered as cracks of the slab, but of the face of the slab, probably due to exposure to a hot sun at low tide during the day and to the cold water of a high tide at night. In addition to these cracks there is a faint crack visible in the top surface of the wall at almost every joint in the cast-iron nosing, the sections of which are 5 ft. long. It looks as if the surface, to a depth of a small fraction of an inch, had cracked where not held by the nosing acting as a reinforcement. These cracks are doubtless due to shrinkage in setting. The wall is founded on solid hardpan.

Fig. 3 shows a wall that was built last summer, east of the dry dock entrance; there is as yet no fill behind it. It is in general the same as Fig. 2, except that the buttresses are on the face instead of the back. These buttresses, being on the south, interrupt the continuity of surface exposed to the direct rays of the sun. The two sections of this wall which have been built are one of them 70 ft. long and the other 110 ft. long. Not a crack of any kind is visible in either section.

Fig. 4 shows a section of the form of construction adopted in rebuilding in concrete the upper altars of dry dock No. 1, in connection with the building of a crane track, with foundations, around the dry dock. The structure is founded on piles. There is no longitudinal reinforcing steel in this section. A cast-iron tongue and groove expansion joint was installed at intervals of 100 ft. At the end of the dock, where the alinement of the crane track carries it away from the dry dock coping, the conduit was widened accordingly. At these places reinforced-concrete beams carry the roof slab, which itself is reinforced with expanded metal.

The expansion joints appear to be in action, though to only a slight extent. Those at the corners of the dock where the dock begins to narrow toward the head show the greatest motion, about 1/8-in.

There are no cracks of importance in the structure, and none that go through the entire section. There is one crack in the crane rail support, or foundation, which is believed to have been caused by the necessity of running the crane upon that part of the work too soon after completion. There is, on an average, one crack through the altars in every length between expansion joints, and in 50% of these the cracks extend through the roof of the conduit. They are barely discernible on the inside of the conduit. There are two cracks in altars and roof at each of the two corners at the head of the dock, which are believed to be largely due to settlements, as the nature of the subsoil is very irreg in this neighborhood. There has in the pa some bulging of the wooden altars here.

There are also occasional slight cracks the tops and faces of the altars and on the ing top which do not go through the concre and are only surface cracks probably due to ink- age in setting. The surface of the pa ent where expanded metal reinforcement wa sed, as noted above, is in excellent condition. ing entirely free from surface cracks.

From these data it is considered that use of either expansion joints of proper desi and location, or of sufficient metal reinforcemen will prevent cracks through the structure, bu hat neither will prevent cracking of the surface ere exposed to sudden changes of temperatu or because of shrinkage in setting, unless th sur- face concrete be specially provided for. his naturally follows from the fact that conc te is a poor conductor of heat, and that consequently the temperature of the inside of the mas will change but slowly. The action of the outer sur- face is thus very different from that which goes on in the interior, and numerous surface cracks appear.

The expansion of a mass of concrete, longitudinally, is partly absorbed by the weight of the concrete and its friction against the foundation, so that the actual movement at the expansion joints is from one-eighth to one-half that which would occur if the mass moved freely, and in accordance with the extreme variations of temperature.

The setting cracks of the surface may be prevented to a large extent by the use of metal reinforcement, equivalent to No. 10 gage 3-in. mesh expanded metal, 2 to 4 ins. below the surface.

In the case of a large area of approximately horizontal surface, the expanded metal may be omitted, but the upper 4 ins. of the concrete should be entirely separated from the main body of the concrete by a tar paper joint, and be free to move independently of the remainder of the mass, being provided with expansion joints arranged to form squares of not more than 40 ft. Expansion joints in the lower body need not be so numerous, or in the case of a large mass may even be omitted altogether.

Expansion joints in walls, if used, should not be more than 75 ft. apart.

*Civil Engineer, U. S. Navy. Navy Yard, Puget Sound, Washington.

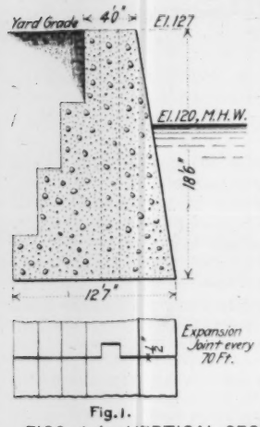

Fig. 1.

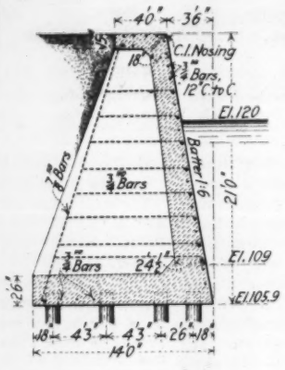

Fig. 2.

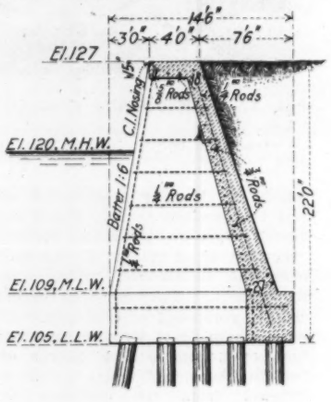

Fig. 3.

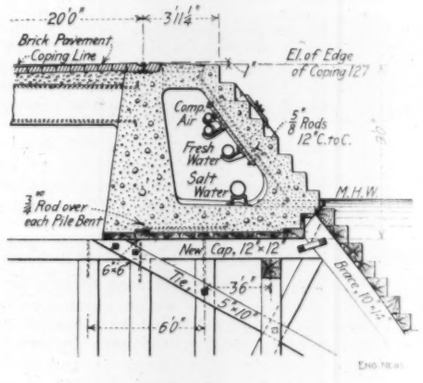

Fig. 4.

FIGS. 1-4. VERTICAL SECTIONS AND PLANS OF CONCRETE RETAINING WALLS AND DRY-DOCK CRANE TRACK, NAVY YARD, PUGET SOUND, WASHINGTON.

(Figs. 1-3 are quay walls; Fig. 4 is crane track on dry dock.)

THE JERSEY CITY TERMINAL of the Pennsylvania R. R. is to be improved and added to at a cost of approximately $300,000. In spite of the fact that this company has in course of construction on Manhattan Island an immense terminal which will take care of most of the travel in the metropolitan district, it is thought that the increase in traffic which this new terminal will bring in connection with all the improvements on the Washington and New York Division, will be reflected to a great extent onto the Jersey terminal. A special feature of the additions to this station will be the provision for immigrants, for whom a large waiting room, 160 × 120 ft. in size, is to be built.

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What is the surest and most economical method of keeping asphalt pavements in repair? That such pavements are not kept in good repair in most cities where they have been laid, even though large sums are disbursed for the purpose, is a well-known fact. The time-honored method of making the contractor responsible for maintenance during a long period of years is now in disfavor with engineers and city officials who have experienced its many drawbacks. Fortunately we need not attempt to answer the question raised by our opening sentence, since the whole subject is ably discussed, elsewhere in this issue, by a well-known engineer who has had much experience with asphalt, including the managership for some years of a large asphalt company. In brief, Mr. Whinery proposes that asphalt contractors be held responsible for pavement maintenance only long enough to make them financially interested in doing good work. That is, in place of the old ten-year and the later five-year guarantee-periods, he would substitute a period of two or at most three years. This plan would soon throw upon the city the whole troublesome problem of asphalt maintenance. This Mr. Whinery would meet by letting out-and-out contracts for asphalt maintenance, thus separating repair work and costs, as they properly should be, from construction. Since little or no competition could be expected for repair work alone, Mr. Whinery suggests that the city protect itself against unfair prices by providing and maintaining a repair plant of its own (as a number of cities, for one reason or another, already have done). The several advantages of this plan, aside from its main object, and the best way of handling the whole matter, are set forth in detail and with clearness and force by Mr. Whinery. We would call particular attention to Mr. Whinery's suggestions as to accurate cost-keeping for repair work, including interest and depreciation charges on capital investment. It may also be mentioned that the proposed repair plant would aid a city in securing reasonable bids for asphalt construction, since in the absence of such bids it could use its repair plant for such work. In conclusion, a point not mentioned by Mr. Whinery deserves consideration: Where the cost of improved pavements is assessed upon abutting properties, long-term maintenance guarantees really add the cost of repairs to the construction costs, and thus may work an injustice to abuttors. This injustice is most serious where some streets are paved without any maintenance clause in the paving contract.

Last month occurred the first anniversary of the California earthquake. It was on April 18, 1906, that the seismic shock came and the conflagration started that swept clean four square miles of San Francisco's business and residence district. It took at least two months to meet the necessities for hand to mouth living, but during the ten months remaining, building has gone on apace, notwithstanding all the disadvantages of deficient labor and materials, so that now nearly every block of the burned district is dotted with new structures. A vast sum, somewhere between fifty and seventy-five million dollars, has been spent on building work alone. The commercial life of the city is in many respects completely restored. The bank clearings are larger now than just before the earthquake.

While everyone must admire the spirit of enterprise and hustle that has wrought such vast results in so short a time in the face of difficulties unprecedented, every well-wisher of San Francisco must regret that the plans for rebuilding the city on a better and safer plan appear to have all come to naught. It was a truly remarkable exhibition of the dauntless temper of San Francisco that even while the fire was still burning, its citizens discussed ways and means of building a new and better city. They said in substance: "Our old city grew up hit or miss, without good location and plan, with combustible, poorly-built houses densely crowded together, part mining camp, part twentieth century metropolis, and the resulting conditions could at no time be remedied and changed for the better because it was not possible to make a clean sweep. Now that the fire has come and made a clean sweep, we can start afresh and build a city with properly located streets and with buildings planned in advance to meet the dangers of fire and earth shock."

Such were the plans that were made while men awaited the time when conditions should permit the work of rebuilding to begin; but when that time came the need of haste caused the plans to be laid one side. The need of each citizen was to get into habitable and workable quarters and re-establish his business there. The matter of drawing up and adopting a city plan was quickly buried. The new city which is rapidly coming into being will be as much the product of chance arrangement as was the old. Control of building construction to secure safe and proper conditions had equally to yield to the necessities of producing shelter of any kind. Of the thousands of new structures erected in the Burned District all save a very few are flimsily built of wood. Even those of permanent construction—steel-frame buildings or concrete buildings—fall in many cases far short of the requirements of good practice.

Doubtless it must be accepted as a fact that the opportunity for making any radical revision of the street system of the city, which was presented a year ago has now passed. For the city's own preservation, however, the character of the building construction must sooner or later be radically altered. Proper building ordinances must be enacted and enforced. It is not possible now nor will it be at any early date to compel the removal of the temporary buildings; but it is not too soon to look ahead and provide for their compulsory removal at a future date. It ought to be practicable to-day to enact ordinances requiring structures of a specified sort, within such and such limits to be removed by 1908; other structures in wider limits by 1909, and so on, until say five years from now the last of the "temporary shacks" shall disappear in all districts where the public safety demands a better class of structures.

Of course, it is recognized by everybody in San Francisco that the temporary structures are to be only temporary. Concretely it is recognized in the provision governing the temporary structures, that any one of them must be removed within 30 days after the city authorities give notice. This provision, on its face, gives ample power to the city to compel the conversion to permanent construction at any time.

The danger is, however, that the interests behind the maintenance of these temporary shacks may become too great to permit the passage of an ordinance to wipe them out. The liberty to erect structures of this sort even retards the erection of a better class of structures. If a property owner knew in advance the date at which a proposed temporary building would become illegal, he would be less likely to erect such a building. Further, if he erected a temporary building in the face of such an ordinance, he could not then effectively plead that the city was injuring him by compelling its removal.

We believe, therefore, that no time should be lost in preparing and enacting such a schedule as we have outlined. Unless San Francisco expects to remain permanently a city of timber shacks it should promptly lay the proper foundation for new and substantial construction.

EXPANSION AND CONTRACTION IN CONCRETE STRUCTURES.

The introduction of expansion joints in masonry and particularly concrete structures is a concession which the practical man makes to the theoretical investigator. The ordinary builder's view of expansion in masonry is very well shown in the following extract from a trade publication:

> Expansion joints are a delusion, soon becoming expanded joints and remaining so. Concrete, to have a surface not perceptibly affected by either heat or cold, should be rigid and monolithic. Blocks once dislodged by frost or by wave force do not fall back into place.

Cracks do occur in structures which are provided with so-called expansion joints—and from the very presence of such joints, designed to take up any movement due to temperature or shrinkage, the natural conclusion is often reached that the failure is due to some cause other than that for which the joint was designed. For instance, a concrete bridge company has recently issued a catalogue containing this statement:

> Cracks in spandrel walls, copings and railings are more often due to settlement in striking centers than to expansion or contraction of the arch;

but as a concession to the believers in expansion joints such joints are provided where desired.

The numerous instances of failures due to expansion and contraction noted in Mr. Lewerenz's paper, elsewhere in this issue, and in Mr. Bellinger's paper* on a similar subject in our last issue, all show very surely that this expansion and shrinkage is not a myth of the laboratory.

That concrete monoliths move under a change of temperature is certain; how much they move has never been determined authoritatively. For several reasons the small scale tests and the expansion coefficient in concrete do not hold in the large mass. The test pieces are so small that it is probable that the whole piece reaches the temperature indicated by a thermometer on its surface. The actual work is always of such a size that the same temperature can never exist in all of its parts, and not only is the average temperature impossible to determine, but the differing temperatures at various parts of the body cause different amounts of expansion and so induce indeterminate stresses.

So also with shrinkage stresses. The amount of shrinkage due to the setting of the concrete is dependent principally on its constituents and methods of mixing. So the ratio of shrinkage is a very hard matter to determine even in test pieces; how much harder will it be to compute stresses induced by shrinkage in a large work.

Nevertheless, such stresses exist, and although they cannot be measured exactly, methods are devised to take care of them. In the two papers noted, two schemes of caring for the partially indeterminate stresses are given. Either the monolith is separated into blocks, each individually capable of caring for its own deformation, or extra reinforcing rods are introduced to take care of the added stress due to the attempted movement in the masonry.

From all the data at hand, it is figured that

*Many other examples were submitted by Mr. Bellinger, but had to be omitted from lack of space.

an extremely high percentage of steel must be added in the latter method; so high, in fact, that it appears to be most uneconomical. It should be pointed out, however, that the manner of making this determination, while based on correct theory, is figured with constants the accuracy of which in large work is entirely a matter of rather scientific guessing. To throw out this method altogether on the strength of such doubtful assumptions is hardly warranted. However, as nearly all long continuous concrete walls, reinforced and plain, show breaks at regular intervals varying with the local conditions, it must be admitted that there is some basis for the computed stresses due to these changes, and that to take care of them by reinforcement solely is dangerous. The more rational solution is, therefore, the one often resorted to; that is, to reinforce for stresses through a certain length, somewhat longer than the distances at which cracks occur in non-reinforced walls and divide the entire length into a number of these units, each separated by an expansion joint. Such a solution applies more generally to walls of dry docks and reservoirs, which must be waterproof. The fewer expansion joints in a waterproof structure, the better its purpose is served.

The problem of expansion and contraction is largely dependent on the position and condition of the structure in question. A retaining wall founded on solid rock has a certain friction between the base of the wall and the rock in addition to the natural adhesion of the concrete to the rock. Before the wall can move bodily, the stresses due to expansion and contraction must be greater than the friction plus the adhesion. If the wall is founded on piles, the forces of deformation must be great enough to bend the piles if movement is to occur. It is quite within belief that the deforming forces will not be great enough to overcome these reverse forces, in which case the action of a sliding joint is made impossible. In a very high wall, however, the bottom may be held rigid by the reactions and the top move under the expansive effort, in which case a distorted section is formed and a tendency to crack occurs at the top of the wall. This still more complicates the proper design of a joint. Thus in a wall all the conditions are against the successful action of an expansion joint, and it would seem more plausible to put in extra reinforcing rods with widely separated expansion joints as an added factor of safety.

On the other hand, the spandrel arches of a concrete arch are often fixed at one end and allowed to move at the other on some sort of a sliding joint. Here it is an extremely simple matter to construct a sliding joint with a low coefficient of friction and, there being no opposing reactions, the whole arch is free to move thereon. An attempt to take up such stresses by extra reinforcement would be bad practice.

A systematic and complete study of this subject has never been made. The information available regarding expansion joints and the study of expansion and contraction in masonry is largely in detached form and peculiar to the individual engineer. The development of the subject is worthy the serious attention of every engineer and a work the value of which would be appreciated by all who are interested in concrete construction, for there is no doubt that the improper and careless treatment of the stresses due to causes other than the natural loading is responsible for much that is troublesome in concrete work.

SOME RECENT DEVELOPMENTS IN RAILWAY BLOCK SIGNALING.

Within the past few years there has been a remarkable development in the introduction of block and interlocking signals, and a corresponding development in the improvement of signal apparatus, while the installation of block and interlocking signal equipment promises to form a considerable item in the general work of railway improvement for some years to come. The probable intervention of the government (through the Interstate Commerce Commission) in making compulsory the use of the block system will undoubtedly tend to continue and increase the activity in this particular direction. It may be predicted with confidence that this new line of governmental intervention will ultimately have the same beneficial results to the public and to the railways themselves as those which have attended the similar movement inaugurated several years ago in regard to the compulsory use of automatic couplers and train brakes. This latter movement has been carried out almost to its entirety, and the beneficial character of the results are now generally admitted. It must be remembered, however, that government intervention on these latter points was strongly opposed by the railway interests, and it is to be expected that the same interests will make similar opposition (directly and indirectly) to the proposed compulsory adoption of the block system.

The report made by the Commission in February showed that about 90 railways with 143,616 miles of road (from five miles to 8,870 miles each), had 48,743 miles equipped with block signals; of this amount, 41,916 miles had non-automatic and 6,827 miles had automatic signals. The report also indicated the rapid growth and probable great development of the automatic signal system. The Commission recommended that the use of the block system should be enforced on passenger lines, compliance with this to be made within three or four years. Unfortunately, no action was taken by Congress at its last session, but there can be no doubt that a law to this effect will be passed before long.

Coincident with the increasing use of signaling systems there has been an active movement towards the standardization of both apparatus and methods of practice. Very satisfactory progress in this direction has attended the work of the Railway Signal Association and the American Railway Engineering and Maintenance of Way Association. These associations, through their respective committees, have worked together in harmony, with gratifying results, and it is now proposed to endeavor to secure the cooperation of the American Railway Association. It is evident, however, that the first named association has in view the adoption or recommendation of a system of block signals differing materially from established practice. While this system, which is described elsewhere, has been in use for only a short time and upon a short stretch of track, it is strongly advocated by the Association. It undoubtedly involves additional complication in the apparatus and in the variety of indications given to the enginemen, but it is claimed to have very material advantages. As the proposed system is fully described elsewhere we need not deal with it here, except to explain the following general features:

1. Two lights and two arms in combination comprise each signal indication; 2. Separate and distinct indications are given by the same type of signal for both block sections and interlocking limits; 3. Separate and distinct indications are given for high-speed and moderate-speed; 4. Each of the two semaphores for any one indication has three positions for the arm and three lights for the lamps; 5. At interlocking plants, the signals indicate for speeds rather than for routes; 6. A small arm and low-power lamp placed low down on the post govern low-speed movements and such subsidiary movements as are usually controlled by hand signals.

The semaphore type of signal is now adopted in the great majority of cases, although some important roads continue to extend their use of the disk or banjo type for block signals. An important change which has been suggested at different times in the past few years, and which is now being advocated very vigorously, is the movement of the semaphore arm in the upper right-hand quadrant instead of the lower quadrant. In other words, the movement of the arm is upward (instead of downward) from the horizontal ("stop") position to the inclined ("caution") and vertical ("clear") positions. Although the upward inclination for the "caution" position has been used on some roads for a number of years, the general adoption of the upper quadrant principle has not until very recently received general appreciation. It was approved in 1905 by signal engineers of the New York Central Lines, and at the present time it has been recommended for adoption by the Railway Signal Association and by the American Railway Engineering and Maintenance of Way Association. It should be noted, however, that the recommendation of the part of the latter association was adopted by a somewhat doubtful vote; the votes in favor were very few, and those in opposition still fewer. Evidently the members in attendance at the meeting took little interest in the matter or did not feel willing (or qualified) to take a definite position one way or the other. On European railways the general practice is to make the movements in the lower quadrant, although a few railways pivot the arm at the middle instead of at the end. In Germany, however, the movements are in the upper quadrant, as was exemplified in the very elaborate signal exhibit of the German Railway Association at the St. Louis Exhibition in 1904.

In the report of the Committee on Signaling and Interlocking, presented at the annual meeting of the American Railway Engineering and Maintenance of Way Association, three reasons are given as those upon which signal engineers and operating officials base their opinion that the "upper-quadrant" arrangement should be adopted: 1. The signal indications thus given concur more nearly with the customary standard hand and lamp signals; 2. The signal construction is more perfect mechanically, as any extraordinary weight (such as snow or ice) on the signal arm tends to place the signal at the "stop" position instead of at the "caution" or "clear" position. 3. There should be a slight reduction in the cost of maintenance and operation, particularly in block signals, owing to reduced power required for operation. The first of these appears to be rather insignificant. There also seems to be but small liability of a signal being actually moved by snow or ice, although it has been stated that this extra weight may vary from "a few pounds to 25 or 30 lbs., or even more." An advantage which appears to have been overlooked is that the arm standing upward is much more conspicuous than the arm hanging down beside the post.

The third advantage noted above is the most important, and should have been explained at greater length, as its importance is not made clear by the statement quoted. A special feature of the advantage in power economy, for instance, is in regard to the counterweighting of the arm as required for the ordinary movement in the lower quadrant. A comparatively heavy counterweight must be employed to raise the arm to the horizontal position, and as the effect of this may be neutralized to some extent by the collection of snow, ice or sleet on the blade (as already noted), a certain excess amount of counterweight must be provided to allow for this excess weight on the arm. This heavy counterweighting necessitates heavy construction and results in severe blows upon the stops at each end of the stroke, with consequent shock to all the parts. In the description of the new signal system now being tried on the Pennsylvania R. R., in which the upper-quadrant arrangement is used, it is stated that the arm is pulled to the "clear" position by a $^{5}/_{16}$-in. rod, instead of being pushed by a ¾-in. pipe or 1-in. rod; which construction saves considerable power. In order to reduce the counterweighting with the lower-quadrant arrangement, it has been usual to place the arm casting for the colored glasses or roundels on the opposite side of the pivot or shaft, so as to help balance the arm. A more distinct indication is given, however, when both the arm and its casting are on the same side of the point of rotation; this arrangement is adopted when the arm is made to move through the upper quadrant.

The special economy of the upper-quadrant arrangement for the battery-operated automatic signals now so extensively used in this country is shown in the following quotation from a paper read before the Railway Signal Associa-

tion by Mr. L. R. Clausen, Signal Engineer of the Chicago, Milwaukee & St. Paul Ry.:

The excessive counterweight must be lifted day after day and month after month in the operation of the signals merely to provide safety during perhaps the one or two hours in a year when the conditions are unfavorable. This is not a serious defect when the signals are manually operated, or where a power plant is used; but it becomes a very important argument against the present practice where primary and storage batteries are used for the operation of the semaphore, and the watt consumption for signal movement has to be considered. As the greater percentage of automatic signals are operated by primary or storage cells, and as automatic signals are now being (and will continue to be) installed very rapidly, this latter question is of ever increasing importance.

Another notable feature in the recommendations of the Railway Signal Association, and embodied in the new system on the Pennsylvania R. R., is that two arms and two lights are to be used for each indication. One reason for using the two-light system is that if one light gives out there is another to warn the engineman of the location of the signal so that he will not fail to notice it. If he sees a signal with only one light he knows there is something wrong. It is also said that a two-light signal is more easily distinguished or "picked-up" by an engineman, especially at large terminals where he is confronted by a great number of signal lights on various posts or bridges. In fact the Superintendent of the Pennsylvania R. R. division on which the new system is being tried has reported as follows, after three months experience:

The two-light feature of the signals is especially valuable in enabling the engineman to pick out his signal at night from among clusters of lights which are found at various points along all railways. This feature alone, in my opinion, more than pays for the original cost and expense of the dummy arm and light.*

With the adoption of this system, advantage has been taken of the two lights and arms to utilize them for different classes of signals and to give a variety of indications. Thus two red lights are placed in varying positions to indicate three classes of "stop" signals, as follows: (1) Vertically (6 ft. apart), to indicate "Stop until signal changes to indicate proceed"; this is for use at interlocking plants. (2) Obliquely (2 ft. horizontal to 6 ft. vertical spacing), to indicate "Stop, then proceed after waiting a prescribed time"; this is for use at automatic block signals. (3) Horizontally, to indicate "Stop for open switch," "Stop for train orders," etc.; this is for use as an information signal, or one not relating to train rights. The varying relative positions of the two arms by day, and the varying colors of the two lights at night, enable a variety of indications to be given. Thus separate indications may govern for high-speed and moderate-speed routes. The advisability of using the two-light system is by no means universally approved, and has been seriously questioned both by operating officers and by signal engineers. Still greater doubt has been expressed as to the advisability of giving such a multiplicity of indications, which may result in confusing the engineman who has to keep in mind the meaning of the various combinations.

There may, however, be a still further variation in signaling by the use of special and distinctive indications for low-speed tracks and side tracks. Such a plan has been under consideration for the New York Central Lines. At terminals there are usually a number of auxiliary or subsidiary movements on main track which are made within interlocking limits under the control of hand signals. These include such movements as those of switching engines in attaching or cutting off sleeping cars (of connecting lines) or dining cars of trains standing beyond the block signal. At a meeting of the Railway Signal Association this question of hand signaling was discussed, and the weight of opinion was that track layouts and signals should be so arranged as to provide for signaling all necessary movements. This would ordinarily be done by means of dwarf signals. In the new system of signaling on the Pennsylvania R. R., already mentioned, and which it is proposed to adopt for the extensive new terminals of the Pennsylvania R. R. and Baltimore & Ohio R. R. at Washington, D. C., a small arm and low-power lamp are provided considerably below the two main arms. These govern slow-speed movements at sidings, crossovers, etc., and at terminals they will also provide for auxiliary movements of the character mentioned.

*In some cases one of the arms is fixed, or a "dummy," as explained elsewhere.

At interlocking plants, the usual arrangement has been that the top arm governs the main or high-speed route, and the lower arm the diverging route, and with a third arm if necessary for an additional route. As to the necessity of the two-light system for each signal, Mr. A. H. Rudd, Assistant Engineer of the Pennsylvania R. R., made the following remarks at the annual meeting of the American Signal Association in October, 1906:

This proposition of two lights on every high-speed signal is one of two or three points that have been developing for some time. It developed that where we had one, two, three and four lights on the signal, if the top light went out the four-arm might be taken for a three-arm; or the two-arm might be mistaken for the one-arm. There have been a number of accidents to trains taking the cross-over at too rapid a rate on account of a light being extinguished. On a one-arm signal the man might notice a possible marker, would not know where to stop, and would overrun the signal. If the lights were always perfect, there would not be any need for more than one light, but they are not and never will be, and we have thought it would be proper to get away from one, two, three and four-arm signals and display on each signal two brilliant lights and no more. But on an interlocking signal, where the low-speed (third) arm is used, the light should be short range and not visible at any great distance. I believe it is the crucial point in signaling to have two lights on signals, so that the signal in itself shows that it has been properly displayed. The cost of the extra light with the long burners, such as we are using, is not very great when compared to the added safety required.

It has been demonstrated that the two lights can be seen at a distance of 3,000 ft., as shown by signals which we put up experimentally; this is proved by enginemen using them, and they are generally pretty conservative about any changes. An important point is that you do not need to see whether they are diagonal or vertical,* until you stop 10 ft. away. The object of making them vertical or diagonal is to distinguish whether they are "stop" signals, or "stop and proceed" signals. If they are red, it means stop anyway, no matter whether they are diagonal or vertical. After a man has stopped, if the red lights are diagonal, he can proceed. To an engineman running, it does not make any difference whether they are diagonal or vertical, because if he gets a clear signal he proceeds, no matter what it is, and if he gets a caution signal, he knows he has to stop at the next signal.

The three-position signal is a feature of signaling that has been much discussed and has been applied in various ways. Where used it is of the semaphore type, for while a three-position disk or banjo signal is evidently practicable for both position and color (and has been suggested at different times), we believe such a signal has never been used in service. The three-position signal (indicating "clear," "caution" and "stop") was first used for permissive blocking with the manual signal system. Thus with a train in the block section, a second train could be given the cautionary or permissive indication "Proceed under control." As a rule the semaphore worked in the lower quadrant, in conformity with ordinary signals, being held at the vertical, inclined (45°) and horizontal positions respectively for the three indications. On the Erie Ry. with the Mozier system, and also on the Atchison, Topeka & Santa Fe Ry., the arm was held at 45° above the horizontal to indicate "caution," and at 45° below the horizontal to indicate "clear." This was described in our issue of March 30, 1899.

The three-position signal was afterwards adapted to automatic signaling, dispensing with separate distant signals. In this case the indication was not permissive, but for overlapping or subdivided blocks. At the inclined position it indicated that the block was clear to the next signal, which was then at the "stop" position. At the horizontal position it indicated that the block was clear to the second signal in advance. There was an economy due to combining the two signals (home and distant) in one, while the arrangement practically lengthened the blocks by indicating for two blocks at each signal. The two-arm system has to a large extent superseded the three-position block signal. Here each post carries two arms, each of which has only two positions; the upper arm indicates for the first section of the block, or to the next signal; the lower arm indicates for the second section of the block, or to the second signal. In the new signaling system of the Pennsylvania R. R. the two-arm and three-position arrangements are combined, each signal having two arms (and lights), which can be set at three positions (showing different colors). This combination has been adopted in order to give a great variety of indications, as already noted.

*Two red lights in a diagonal or oblique line indicate "Stop, and proceed after waiting." Two red lights in a vertical line indicate "Stop until signal changes."

As to distinction between block and interlocking signals, there is no uniformity in practice, and this is one of the important points which calls for the attention of the various signal associations and committees. On some roads, the interlocking signal indicates both for the route and the block; this is generally considered as extending the interlocking limits undesirably, especially with long block sections. On other roads there are distinctive signals for the blocks and the interlocking plants, and in some cases the block signal nearest to the interlocking serves as an advance signal for the latter. There are numerous combinations of, and variations from, the above general methods.

In regard to present prevailing practice in block signaling it may be said that the use of the semaphore type of signal is now almost universal, although some important roads are still continuing and extending the use of signals of the disk or banjo type. On lines with heavy traffic, and particularly near large cities, the use of the double-arm signal indicating for two blocks in advance is now very generally adopted, owing to the extra safety and facility of operation thus obtained. This system as used on the Boston & Maine Ry. was described in our issue of March 7. While the distant signal (and the lower arm on a two-arm signal) is usually made with a forked or fish-tail end, and while some railways used a pointed arm for train-order or other signals, there seems to be a movement in favor of making all arms with square ends. As to the colors of lamps for night indications, there is a strong tendency to eliminate the white light altogether, and now that a satisfactory yellow light has been introduced (after much experimental work) this tendency will increase. The colors adopted as standard by the Railway Signal Association and the American Railway Engineering and Maintenance of Way Association are as follows: Red for "stop," yellow for "caution," green for "clear." The automatic signal system is making remarkable progress, and out of 48,743 miles of road equipped with the block system, 6,827 miles have automatic signals. The report of the Interstate Commerce Commission, which gives these figures, makes the following remarks as to automatic signals:

Automatic block signals, almost universally looked upon in this country as the highest exemplification of the art, have been and are being developed with great energy and skill and liberal expenditures of money. Automatic signals are superseding the telegraph block system to some extent, and seem destined to do so increasingly in the future.

In conclusion we give the recommendations presented by the Committee on Signaling and Interlocking at the annual convention of the American Railway Engineering and Maintenance of Way Association. The only ones adopted (and the only ones submitted for such definite action) are the first three of No. 2 (A, B and C), which had already been adopted by the Railway Signal Association. In addition to the series of block signal indications given, the committee included others giving special information for switches, train orders, speed reduction, location of track tanks, etc. These we omit, as they do not bear upon the matter of block signaling, and in any case they are only tentative.

1. SIGNAL INDICATIONS.—The following indications should be considered as those which are required in a complete system of signals:

Indications Restricting Rights.

1. Stop at (or before) reaching, and stay.
2. Stop at (or before) reaching, and then proceed cautiously.
3. Prepare to stop at next signal.

4. Proceed under control; block is occupied.
5. Take siding at next station.
6. Proceed on high-speed route, prepared to stop at next signal.
7. Proceed on limited-speed route, prepared to stop at next signal.
8. Proceed on slow-speed route, prepared to stop at next signal.

Indications Conferring Rights.

9. Proceed, block is clear.
10. Proceed, block clear and next signal at proceed.
11. Proceed on high-speed route, next signal at proceed.
12. Proceed on limited-speed route, next signal at proceed.
13. Proceed on slow-speed route, next signal at proceed.

2. PRINCIPLES FOR SIGNAL INDICATIONS.—The following principles of giving indications should govern in formulating a system*:

A. On all signals conferring or restricting rights, a red light shall be the night indication for "stop." A yellow light shall be the night indication for "caution,"† and a green light the night indication for "clear."

B. The day indications of semaphore signals shall be given in the upper right-hand quadrant.

C. The semaphore arm horizontal shall indicate "stop"; inclined upward 45°, "caution"; and inclined upward 90°, "proceed."

D. Two lights shall be displayed on every high speed signal.

E. The "stop" indication shall be given by red lights in a vertical line.

F. The "stop and proceed" indication shall be given by red lights in an oblique line.

G. Lights in a horizontal line shall be used for information signals.

H. Automatic home block signals shall have one arm with end pointed.

I. Interlocking home signals shall always have two full-sized arms representing unlimited and limited (or medium) speeds respectively; and shall have one low-speed arm, distinguished by a greater interval between it and the second arm, than the interval between the top and second arm. A dim light at night shall be used when such low-speed arm is required. The arms to have square ends.

J. The stop indication of dwarf signals shall be given by a purple light.

K. The home signal shall be displayed in the 45° position to indicate that the advance signal is at "stop."

L. Interlocking distant signals shall be provided with two arms.

LETTERS TO THE EDITOR.

Trigonometric Functions of Frog Angle Expressed in Terms of Frog Number.

Sir: The writer has had occasion to derive formulas for computing distances necessary in staking out switches, turnouts, crossovers, etc., expressed in terms not involving trigonometric functions of the frog angles as they were for use by the track men, who had no knowledge of trigonometric terms. He therefore found expressions for the sine, cosine, tangent, etc., of the frog angle expressed in terms of the frog number. These are extremely simple, and in more convenient form for use than those found in regular tables, if the tables are at hand and the use of them is understood. The expressions give exact values.

In the expressions given below, F denotes the frog number and A denotes the frog angle:

$$\sin A = \frac{F}{F^2 + \frac{1}{4}} \quad \ldots(1) \qquad \operatorname{cosec} A = \frac{F^2 + \frac{1}{4}}{F} \quad \ldots(4)$$

$$\tan A = \frac{F}{F^2 - \frac{1}{4}} \quad \ldots(2) \qquad \operatorname{cotan} A = \frac{F^2 - \frac{1}{4}}{F} \quad \ldots(5)$$

$$\cos A = \frac{F^2 - \frac{1}{4}}{F^2 + \frac{1}{4}} \quad \ldots(3) \qquad \sec A = \frac{F^2 + \frac{1}{4}}{F^2 - \frac{1}{4}} \quad \ldots(6)$$

The last three expressions are of course reciprocals of the first three. Their derivation is as follows:

By definition number of frog equals ½ the cotangent of ½ the angle of frog; expressed thus:

$$\operatorname{cotan} \frac{A}{2} = 2F \quad \ldots(1)$$

$$\tan \frac{A}{2} = \frac{1}{2F} \quad \ldots(2)$$

$$\tan A = \frac{2 \tan \frac{A}{2}}{1 - \tan^2 \frac{A}{2}} \quad \ldots(3)$$

Substituting in equations (2) and (3) and reducing:

$$\tan A = \frac{F}{F^2 - \frac{1}{4}} \quad \ldots(4)$$

Again:

$$\frac{F}{F^2 - \frac{1}{4}} = \tan A \quad \ldots(5)$$

$$= \frac{\sin A}{\sqrt{1 - \sin^2 A}} \quad \ldots(6)$$

Solving equation (6) for sin A:

$$\sin A = \frac{F}{F^2 + \frac{1}{4}} \quad \ldots(7)$$

$$\frac{\sin A}{\tan A} = \cos A \quad \ldots(8)$$

Substituting values of equations (4) and (7):

$$\cos A = \frac{F^2 - \frac{1}{4}}{F^2 + \frac{1}{4}} \quad \ldots(9)$$

A. G. Bennett,
Asst. Engr., C., M. & St. P. Ry.
Minneapolis, Minn., April 13, 1907.

*The principles stated in paragraphs A, B and C have been adopted by the Railway Signal Association and the American Railway Engineering and Maintenance of Way Association.

†The word "caution" to be used as indicating the function of a distant signal.

The Measurement of Curved Lines.

Sir: In my contribution on "A Method of Constructing an Ellipse and Measuring the Curved Length," in Engineering News of April 4, 1907, p. 388, no reference was made to the degree of accuracy of the well-known method of rectifying an arc of a circle on its tangent. I desire to show that the approximation is exceedingly close. It will be seen from the figures given below that the very small error involved is dependent upon the value of the angle subtended [that is, the larger the angle, the greater the proportionate error], and that the result within certain limits is practically the same as if the curve were rolled off on its tangent. The draftsman is recommended generally not to apply the construction to arcs subtending angles greater than 60°. In case it becomes necessary to measure an arc subtending a greater angle, it should be bisected and one-half the arc rectified, giving one-half the required length.

Irregular plane curves may be approximately measured by this method. If the curve be a short one and has no point of inflection, as in Fig. 1 herewith, a very fair approximation to its length may be made by measuring

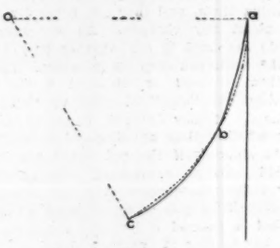


Fig. 1.

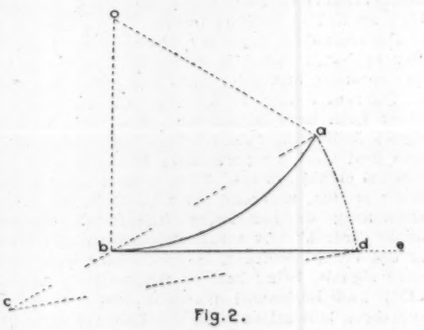


Fig. 2.

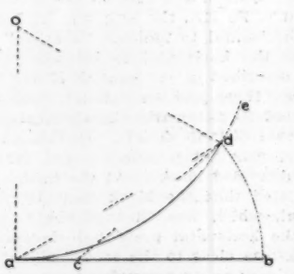


Fig. 3.

the arc of a circle which passes through three points—a, b and c—judiciously selected. If the curve has one or more points of inflection, it may be represented by two or more arcs of circles, the sum of the lengths of which will give the length of the curve. The draftsman may test the value of the method by rectifying [illegible] which has been represented by an assemblage of circles, as explained in the writer's article referred to.

The following tests will supply the information regarding the degree of accuracy for the arc subtending angles of 60°, 45°, 30° and 15°:

Let a b, Fig. 2, represent an arc subtending an angle of 60°. Produce the chord a b to c, making b c = ½ a b. Draw b d perpendicular to o b. From the center c with the radius c a draw the arc a d intersecting b d at d. Then the line b d is very approximately equal to the arc b a. For a central angle of 60°, calling the radius of the arc unity, a b = 1.0; b c = 0.5; c d = 1.0; the angle a b d = 30°; and d b c = 150°. Solving the triangle b c d, the side b d which measures the arc a b = 1.046. The true length = ⅓ π = 1.047; i. e., the error is a very small fraction of the length of the curve. For an arc subtending an angle of 45° the angle c b d = 157° 30'. Solving the triangle c b d, b d = 1.0258. This would be multiplied by 2 sin 22.5° (½ 45°) the length of the chord a b. Thus, 1.0258 × 0.7653 = 0.7851. The true length = ¼ π = 0.7854; i. e., the error is reduced to a still smaller fraction of the length of the curve. By similar calculation, making the central angle of a b = 30° we find that the error is reduced to a still smaller fraction of the length of the curve. When the angle is 15° the error is reduced to an almost inappreciable quantity.

The reciprocal construction, illustrated in Fig. 3, introduces an error which is also small enough to be neglected in practice. Let a d e be an arc of a circle, and a b a tangent of any given length at one extremity a. It is required to wrap this tangent around the arc, and discover where the point b will fall. Lay off a c = one-fourth of a b, and from the center c with the radius c b = ¾ a b describe the arc b d, intersecting the arc a d e at d. The length of the arc a d is practically equal to the tangent a b. The accuracy of the result may be tested. Join a d and c d. When the angle at o subtended by the arc a d = 60°, the angle d a c of the triangle a c d = 30°, the side a d = 1.0 (= the radius) and a c = ¼ a b = 1/12 π = 0.2618. Solving this triangle, we find that the side c d (= c b) = 0.7843. Adding this to 0.2618, we obtain 1.0461. The true length is ⅛ π = 1.0472. Therefore when the construction is applied to as large an angle as 60° the error is less than 0.0011, a very small fraction of the length of the curve. If the angle at o is made 45°, the angle d a c = 22.5°, the side a d = 2 sin 22.5° and a c = ¼ a b = 3/16 π = 0.19635. Solving the triangle, it is found that c d = c b = 0.5888. Adding this to 0.19635 the result is 0.7851. The true length of the curve = ¼ π = 0.7854. The proportionate error is smaller than that involved in the larger angle. The proportion of the error to the length of the arc very rapidly diminishes with the diminution of the angle subtended.

Frederic R. Honey.
Trinity College, Hartford, Conn., April 8, 1907.

The Choice of Steel for Reinforcing Concrete.

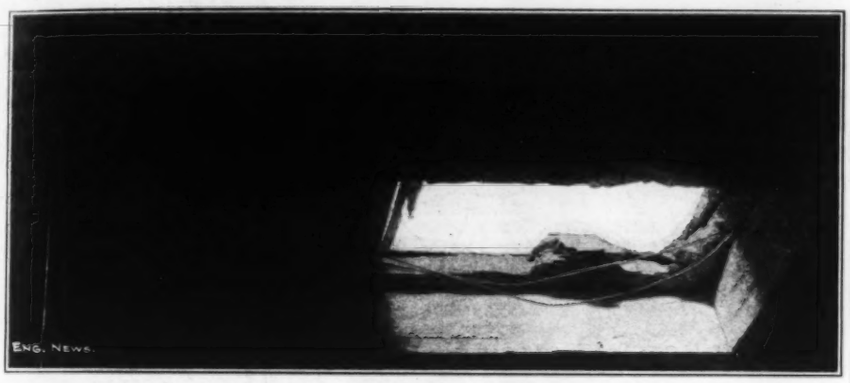
Sir: Steel for concrete reinforcement is now on the market having elastic limits varying from 30,000 lbs. to 60,000 lbs., and with cost varying in the same ratio. The cost of 10,000 lbs. elastic limit per lin. ft. of bar varies widely, the lower limit being generally assumed to be occupied by high-carbon unpatented bars of high elastic limit and low cost per pound; next to these come the high-carbon patented bars, which are as efficient per pound of material as the others, but cost more owing to royalties, etc. Still higher in strength-cost are the unpatented bars of mild or medium steel, and above these again are the patented bars of the same material. The writer has made the comparison in strength and cost of the various types of reinforcement now on the Kansas City market and finds that the cost of 10,000 lbs. elastic limit in a bar 1 ft. long varies from 1.12 cts. to 2.92 cts.

The writer is engaged in making designs for reinforced concrete buildings, which designs are as a rule used in open competition by contractors, the contract being usually awarded (under our present indefensible custom) to the lowest bidder. He has long been of the opinion that in building construction the value of mechanical bond does not justify any material outlay to effect its attainment. He has been accustomed to test his designs for bond failure by means of Talbot's formula for bond stress and has rarely found beams in which the total bond stress in an undeformed bar would be over half developed when the steel reached its elastic limit. Where an increase in bond value was deemed advisable it was obtained by the use of the same area of cross-section in bars of smaller diameter thus obtaining an increase of 50 to 100% in bond value at a cost not exceeding 5 or 10 cts. per 100 lbs. of steel. It is true that bond in plain bars is affected by water, by rust, and by dirt on the bars, but the excess values at the breaking point of the beam seemed ample to provide for such contingencies as would occur in a building. These views, however, do not apply to railway bridges.

Lately, however, the writer has been obtaining me-

chanical bond without increasing the cost of the design; in fact, frequently the cost of a design having mechanical bond is less than the corresponding one of the same strength using plain bars. Under these circumstances, with mechanical bond obtained without expense or even at a saving, there seems to be no reason for not using it very freely. The explanation is simple. Formerly the writer believed that the highest economy in concrete reinforcement was obtained by the use of plain high-carbon bars having an elastic limit varying from 50,000 lbs. to 65,000 lbs. per sq. in., and which can safely be assumed for purposes of calculation at 50,000 lbs. This material is now on the market twisted and is sold at a cost about 10% above the cost of plain bars. Now, if the twisting of this material enables the elastic limit to be assumed as 10% above the elastic limit of plain bars, in other words, at 55,000 lbs., then mechanical bond is obtained without cost, and any safe assumption above this point is a net gain.

The writer has in his possession reports of a large number of tests on this material. The bars were obtained from different mills and the tests were made at different places by different observers, but all upon commercial material not originally intended for test pieces. Without burdening this discussion with a long list of tests, it may be stated that an elastic limit of 55,000 lbs. is a safe assumption for high-carbon twisted bars of ⅝-in. diameter and larger. The average of a series of tests on such bars will be about 60,000 lbs. and not over 5% will fall below the assumed limit. As the diameter decreases below ⅝-in. the elastic limit increases. Tests on ½-in. bars will average above 70,000 lbs. elastic limit and 65,000 lbs. is a safe working assumption. The assumption of an increase of 5,000 lbs. per sq. in. in elastic limit above that of plain bars is justifiable, largely on account of the increased reliability of the material. No system of inspection could be devised which would detect every flaw as surely and accurately as the twisting process, while the twisting actually does increase the strength of the smaller bars very materially. The smaller sized bars are thus affected while the larger ones are not, because the smaller bars cool faster than the large ones and are thus twisted at lower temperatures. The twisting process applied to high-carbon material thus gives us bars of greatly increased reliability and affords mechanical bond with no increase in cost over plain material. It is unpatented, and as there is no great profit to be obtained from exploiting its merits, its use is only beginning to be general.



VIEW OF UNDER SIDE OF HOLE IN REINFORCED CONCRETE ROOF MADE BY FALLING BEAM; SCARRITT BUILDING, KANSAS CITY, MO.

In this connection reference may be made to an accident in the Scarritt Building which is being erected on the corner of Ninth St. and Grand Ave., Kansas City, Mo. This is a 12-story office building having a steel frame of the ordinary type, and reinforced concrete floors. The columns are spaced 14 ft. 8 ins. c. to c. in one direction and approximately 20 ft. 6 ins. in the other direction. The floor girders are 20-in., 65-lb. I-beams running in the long direction of the panel. The only floor beams used are light members at the columns to serve as spacers and struts in the lateral bracing system.

The reinforced concrete floors span 14 ft. 8 ins. from girder to girder, and consist of alternate concrete beams and rows of porous terra cotta blocks, 6 × 12 × 12 ins., laid with their webs abutting. The reinforced concrete beams are 4 ins. wide and 6 ins. deep, each reinforced with two ⅝-in. square twisted bars of high-carbon steel. The tops of the blocks and beams are flush with the tops of the steel girders, and the reinforcing bars lap across these girders and sag down toward the bottom of the beams as they approach the quarter points of the span, being horizontal and within 1 in. of the bottom throughout the middle half of the beam. The ends of the bars overlapping the girders are extended about 1 ft. into the concrete of the adjoining panel but are not hooked over the flanges of the beams. The entire construction is covered with 2½ ins. of concrete in which the wire ducts and nailing strips for the wood floor are imbedded. This, however, had not been laid at the time of the accident.

During the erection of the derrick for handling the structural steel, one of the timbers forming it broke loose and plunged endwise down the light court. This timber was a 12 × 12-in. stick of Oregon fir, 41 ft. long and shod on one end with a goose neck, weighing in all perhaps 2,000 lbs. The weighted end went down first. The timber fell clear and unimpeded for 125 ft., striking on one end on the reinforced concrete roof of the light court over the second story. It tore a hole in the roof construction about 2 ft. 6 ins. wide and 6 ft. 0 ins. long, but was itself snapped short off about 10 ft. from the lower end by the force of the impact. The upper portion of the timber remained on the roof above the opening and the lower 10 ft. passed through at an angle, struck a column about 10 ft. away and fell harmlessly to the floor below. The breaking of the timber is doubtless due to the fact that, on account of the shape of the goose neck, the center of gravity of the stick did not follow directly after the point of impact.

The roof was covered with 2-in. plank to protect the tile from pieces of falling brick, as the concrete filling intended to give the roof its slope was not yet in place. These planks were sheared off at the edge of the opening. The portion of the concrete roof itself which received the first impact was found. The point of the goose neck had evidently struck a tile block, but in passing through, the edge of the socket struck the web of the block which was bedded in the concrete and had sheared the tile edgewise so that only a portion of the thickness of the web remained adhering to the concrete. Under the blow the floorbeam had shattered and two reinforcing bars had sagged, the one which sustained the brunt of the load when the web of the tile was sheared, being noticeably longer. The remarkable thing is that both ends of each bar remained fast in the concrete and neither bar broke. A few blocks on the opposite side of the beam were shattered, and the concrete was stripped from the rods for about 6 ft. The concrete was about 30 days old at the time of the accident. It was well seasoned and the bars did not cut into it. These bars were of high-carbon steel, re-rolled from old steel rails, and furnished by the Inland Steel Co., of Chicago.

The architects for the Scarritt Building are Root & Siemens, of Kansas City. The reinforced concrete floors were designed by the writer and constructed by the Terra Cotta Fireproofing Co.

C. W. Noble, Assoc. M. Am. Soc. C. E.
2005 East Seventh St., Kansas City, Mo.

Notes and Queries.

The Williams and Quimby sections of steel piling referred to by Mr. W. G. Fargo in the paper printed in our issue of April 4, have apparently never been made or used. Mr. Fargo informs us that the sections were taken from Patent Office records, and he believes they have never been rolled.

E. W. H. inquires what variation from a true vertical position would be permissible in the erection of a marble monument or obelisk 34 ins. sq. at the base and 29 ft. high. The obelisk tapers and ends in a pyramid at the top.

THE INLAND WATERWAYS COMMISSION, recently appointed by President Roosevelt, is to meet at Kansas City on Friday, May 10, and will proceed by boat to St. Louis, arriving Monday, May 13. It will go thence by steamer to Memphis and probably to New Orleans. Daily conferences will be held throughout the trip. No invitations for receptions or entertainments have been accepted, although many have been extended. The purpose is to make a personal study of conditions along the Missouri and lower Mississippi rivers.

THE PHILADELPHIA MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The eleventh general meeting of this society was held in Philadelphia, May 2, 3 and 4. The formal sessions were held at the John Harrison Laboratories of Chemistry, at the University of Pennsylvania. Several excursions to industrial plants were taken, and considerable attention was paid to the social side of the meeting.

The excursions included a trip to the plant of the United Water Improvement Co., where the commercial purification of water by ozone was shown. Water containing 3,000,000 bacteria per cc. and various organic substances, had its deleterious matter entirely oxidized and the number of bacteria reduced to less than 5 per c. c. About 10 KW. were used in treating 10,000 gals. per hour. A second excursion was to the plant of the J. F. Lewis & Bros. Co., where the manufacture of white and red lead was shown.

On the second day of the meeting, the city fireboat "Ashbridge" was tendered the society through the Mayor and Director of Public Safety. The members were taken on this boat to the Disston Saw Works, the Lardner's Point Pumping Station and the Lardner's Point station of the Philadelphia Electric Co., where the Disston Saw Works had running, a Colby induction furnace for experimental work in steel. This small furnace has a working capacity of about 190 lbs. of steel at an electrical consumption of 130 KVA. As it works at 240 volts, that means a primary current of 541 amperes. There are 28 turns on the primary coil, which, with an approximation for value of eddy currents in the molten metal, would show about 16,000 amperes flowing through the steel treated. This is contained in an annular trough having a cross-section of 2.14 ins., which gives a current density in the steel of roughly 7,480 amperes per sq. in. It has been demonstrated with this experimental furnace that a 90-lb. ingot can be cast every hour, and that after being thoroughly warmed up, the expenditure of energy per ingot is from 25 to 34 KW. hours, according to the carbon in the steel. It can be started cold by using a steel ring in the trough, though of course the expenditure of energy is large until the entire furnace becomes normally heated.

The same trip on the fireboat included a visit to the Gloucester plant of the Welsbach Co., where the manufacture of gas light mantels was shown in all stages. On the last day of the meeting, the electrolytic refining of gold and silver at the U. S. Mint was shown by Dr. D. K. Tuttle, Mint Metallurgist.

The program of sessions showed 31 papers to be read, but of these many were read by title only and others were entirely omitted. A few were presented in print for discussion. We have very briefly considered those of the most interest to engineers rather than electro-chemists.

"Recent Developments in Electrolytic Analysis," E. F. Smith, Vice Provost, University of Penn. This paper was one of the most interesting presented. It showed the progress in reducing the time of chemical determinations by means of a mercury cathode and a revolving anode. Instances were shown where the hours needed were reduced to minutes and the accuracy increased.

"The Electrolytic Pickling of Steel," C. J. Reed, of the Hercules Metal Co. This brief paper gave facts about removing scale from iron and steel, where the iron became the cathode of an electrolytic process. It was stated that with an acid solution at 60° C. and a specific gravity of 1.75, and with a current density of 1.4 amperes per sq. in. for the cathode, the hardest scale was removed in three minutes. The method was claimed as especially applicable to steel wire where manufacturers could pass the wire lengthwise through the solution. Many firms object to this and prefer to immerse in coils, which prevents a uniform current density, and no good results.

"Determination of Fixed Points in Pyrometry," G. K. Burgess, of the National Bureau of Standards. Work was shown, as carried on at the Bureau of Standards, in determining tempera-

tures above 1,200° C., and determining fixed points suitable for the calibration of pyrometers. Such were the melting points in hydrogen, of manganese, nickel, cobalt, chromium and iron, which establish temperatures up to 1,507° C. The method for these is as follows: A platinum ribbon heated electrically is enclosed in a cylinder which may be filled with pure hydrogen. A very minute quantity of the metal whose melting point is desired is placed upon the platinum. The current is increased until the speck is seen to melt as observed with a microscope through an inner window. Simultaneously the temperature of the strip is measured by means of an optical pyrometer. Points above 1,800° C. are yet rather indefinite, and at the Bureau of Standards a scheme has been used which is a modification of the surface radiation method. Considerable precision may be obtained above 1,800° C. in the determination of the melting points of any substance which can be manufactured into wire or ribbon and which does not volatalize before melting. It does not seem improbable that in the near future when an optical pyrometer is submitted to a standardizing laboratory it may be calibrated at 1,000°, 2,000° and 3,000° C. in less than half an hour.

Dr. C. P. Steinmetz gave an illustrated lecture on "The Conductions of Vapors and Gases." All types of conductors were considered and their phenomena discussed. The properties of arcs and static discharges in gases were shown in considerable detail by special apparatus.

"The Influence of Strain on Corrosion of Iron," Prof. W. H. Walker, of the Massachusetts Institute of Technology. This paper gave results of experiments of simultaneous stress and electrolytic action. Up to the elastic limit there was no change in the e. m. f. of electrolysis, on account of changes in stress or strain. Above the elastic limit the voltage required for electrolytic action rose. On breaking, this e. m. f. immediately fell to normal.

"Electrolytic Corrosion of Brasses," Dr. A. T. Lincoln, of the University of Illinois. This paper received the 1906 award of $100. It showed the results of a line of careful experiments to find the effects of proportions of zinc, tin and copper in brasses, on electrolytic corrosion in solutions of the components of sea water. From these results it is hoped ultimately to derive an alloy resisting action of sea water.

"A Bomb Calorimeter for Measuring the Heat of Combustion of Substances Giving Solid Oxidation Products," Dr. H. N. Potter, of the Westinghouse Electric Co. This new calorimeter has a removable, gold-plated copper shell, inside the usual steel one. The cover for this interior shell is distinct from the bomb cover, and carried the material shelf and, removably, the ignition coil. The entire arrangement of shell, shelf, ignition, charge and cover can be weighed in one operation. The steel cap carries a lead gasket in such a manner that the steel and copper shells are sealed from each other.

Mr. John Meyer, of the Philadelphia Electric Co., presented a reply to a former paper, by Mr. E. A. Sperry, on "Electro-Chemical Industries as Station Load Equalizers." Mr. Meyer claimed that very often cheaper products would result by locating the industry in large cities and using central station power, because of greater accessibility and better shipping facilities.

Mr. E. R. Taylor, inventor and operator of the carbon bisulphide works at Penn Yan, N. Y., showed the construction of a new closed resistance furnace for economically reducing and distilling the volatile metals from ores.

An extensive paper by Dr. C. E. Lucke, of Columbia University, was presented in printed form. It showed relative equipment and operating costs for various types of power generation.

The following officers were elected: President, C. F. Burgess, Madison, Wis. Vice-Presidents, C. E. Acker, Niagara Falls, N. Y.; A. H. Cowles, Cleveland, O.; W. H. Walker, Boston, Mass. Managers, E. F. Roeber, New York City; S. S. Sadt'er, Philadelphia, Pa.; L. Kahlenburg, Madison, Wis. Treasurer, P. G. Salom, Philadelphia, Pa. Secretary, J. W. Richards, Bethlehem, Pa.

THE STRAWBERRY VALLEY PROJECT of the United States Reclamation Service is now under way near Vernal, Utah. It is expected to irrigate several thousand acres from a reservoir of 100,000 acre-feet, created by a dam across the Strawberry River. It is proposed to eventually build a power-house of 2,250 KW. capacity for lighting and pumping service in the irrigated district. A temporary power-house will be immediately built at Spanish Fork, some 33 miles from the dam. The electrical equipment of this power-house will be moved later to the permanent station which will probably be much nearer the dam than Spanish Forks. The contracts for this equipment have been secured by the General Electric Co., and it includes two 425-KW., 11,000-volt, three-phase generators, direct connected to Leffel water-wheels. Transmission to the dam will be at 22,000 volts.

PROGRESS ON NEW YORK CITY'S CATSKILL WATER SUPPLY SYSTEM: DAMS OF THE ASHOKAN RESERVOIR.

The extensive plans developed by New York City through its Board of Water Supply for increasing the present impounding and conduit system which furnishes Manhattan Borough with water are rapidly progressing toward the beginning of construction work. The new supply, calculated to bring 500,000,000 gals. per day to the city, is taken from the Catskill Mountain region, on the west shore of the Hudson River, while the entire present system, drawing from the Croton River region, is on the east side of the Hudson.

The map Fig. 1 herewith shows the initial element in the new supply, the Ashokan Reservoir on Esopus Creek in the western Catskill region. This reservoir will be about 12 miles long, with a maximum width of 2 miles, and will be divided into two nearly equal basins, one in the valley of Esopus Creek, and the other in the valley of the Beaver Kill, a tributary of the Esopus. The waters will be impounded by a large masonry and earth dam across the gorge of the Esopus, and a series of earth dikes closing the valley of the Beaver Kill and adjacent depressions in the rim of the reservoir. This chain of masonry and earth dams will aggregate nearly three miles in length, and its cost is expected to approximate, roughly, 10 to 12 millions of dollars. There will be built, also, a dividing weir between the two basins, and an overflow weir from the eastern basin. The dividing weir is to carry a reinforced-concrete arch bridge, and public highways will extend along the tops of the dams.

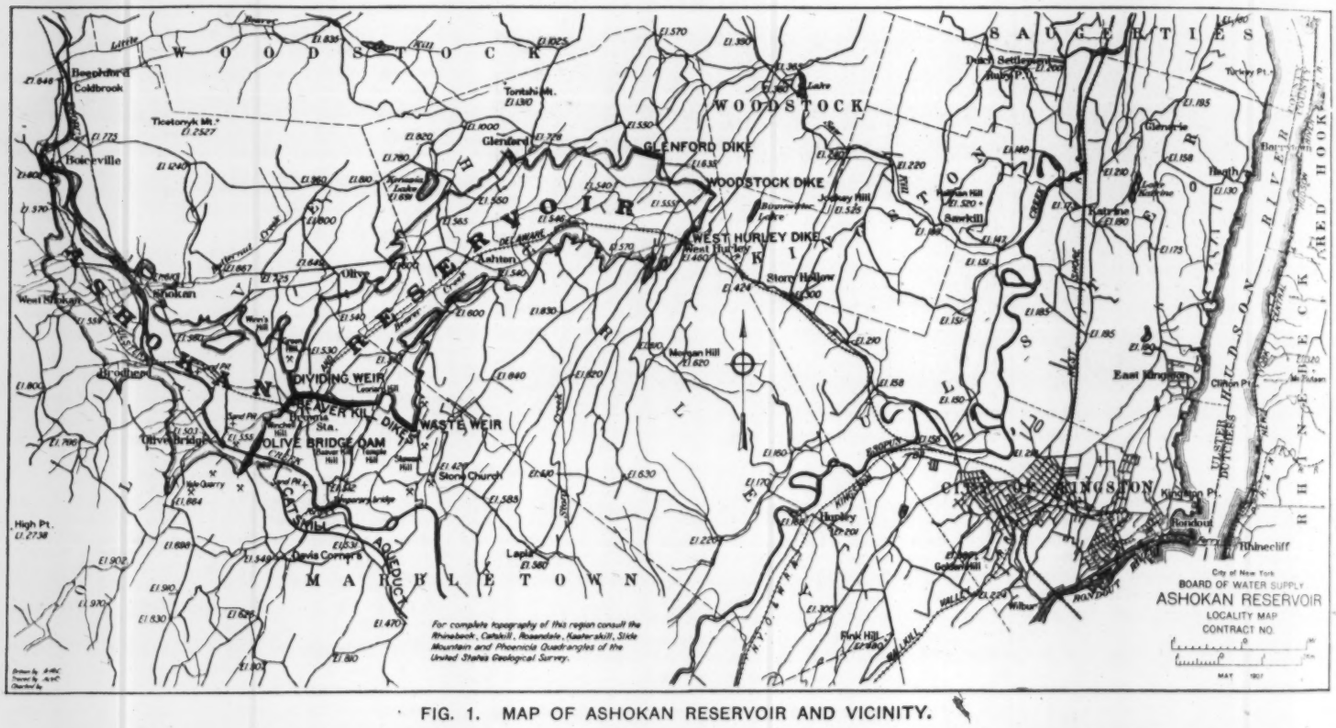


FIG. 1. MAP OF ASHOKAN RESERVOIR AND VICINITY.

The principal dam, that across the Esopus, will be known as the Olive Bridge dam. The photograph Fig. 2 shows the gorge of the Esopus at the site of this dam. The chain of dikes to the east has been collectively designated as the Beaver Kill dikes, distinguished individually as the West dike, Middle dike, and East dike. Olive Bridge dam will have a length of about 5,000 ft. on top and a maximum height in the river gorge of about 220 ft. The central part will be of masonry, with a cross-section as shown in Fig. 3, substantially the same as that of the Wachusett dam of the Boston Metropolitan Water Works at Clinton, Mass. The earth dams, typically represented by the cross section Fig. 4, have liberal sections, and will, besides, have substantial masonry core-walls. Abundance of

FIG. 2. VIEW OF GORGE OF ESOPUS CREEK AT SITE OF OLIVE BRIDGE DAM, MAIN DAM OF ASHOKAN RESERVOIR.

good bluestone is available for the masonry, which will be of cyclopean rubble and concrete, and excellent earthy materials are available for building tight embankments. Sand, also, is found not far from the Olive Bridge dam site. The Ulster & Delaware R. R. crosses the line of the dams, and Brown's Station is near the center of the length of the chain of dams. Olive Bridge dam site is about 1½ miles by road from this railroad station.

Esopus Creek has a drainage area of 259 sq. mi. above Olive Bridge dam site. At the latter point the stream flows in a rock gorge about 40 ft. deep and 200 ft. wide (Fig. 2). Its dry-weather flow is often but little in excess of 100 cu. ft. per sec., a common range for such periods being from 100 to 300 cu. ft. per sec. However, the creek rises rapidly with heavy rainfalls and floods of 2,000 to 6,000 cu. ft. per sec. occur several times during the year. The brief records available show several floods as great as 12,000 to 15,000 cu. ft. per sec., and the maximum of which there is any tradition is estimated to have reached about 38,000 cu. ft. per sec. The watershed of the Beaver Kill is but 17 sq. mi., so that the quantity of water to be handled in this stream during construction is relatively small.

Water will be drawn from both basins through a great central gatehouse located at the junction of the dividing weir with the West dike. While the aqueduct is proportioned for a little over 500,000,000 gals. in 24 hrs., the gatehouse will have a capacity for handling water at the rate of 1,200 million gallons daily, so as to provide for a possible second aqueduct in the future. To lead the water to this gatehouse so as to draw the two basins of the reservoir to low levels, two large channels will be required, one in each basin, excavated partly in rock, with a maximum depth of about 40 ft.

The magnitude of the proposed dams challenges attention. Approximately, 1,000,000 cu. yds. of masonry of all kinds will be required, and there will be nearly 6,000,000 cu. yds. of earth in the embankments. Another notable element of the work is the urgency for rapid construction, as the city is in great need of more water.

The first contract of the Catskill supply, covering nearly 11 mi. of the Catskill aqueduct in the vicinity of Peekskill, has already been let, the contractor being the Thomas McNally Company, of Pittsburg, Pa. Active preparations for construction under this contract are now being made. The designs for the main dams of the Ashokan reservoir are nearly completed, and the Board of Water Supply will soon be ready to advertise for bids. It is expected that active construction can begin during the summer.

Additional information can be obtained at the main offices of the Board of Water Supply, 299 Broadway, New York City, from J. Waldo Smith, Chief Engineer, or Alfred D. Flinn, Engineer of Headquarters Department, who have kindly furnished the material from which these descriptions and illustrations were prepared. Mr. Carleton E. Davis is Engineer of the Reservoir Department, and has an office at Brown's Station. Appointments can be made for visiting the sites of the dams, and intending bidders would do well to become thoroughly informed concerning the field conditions at an early date.

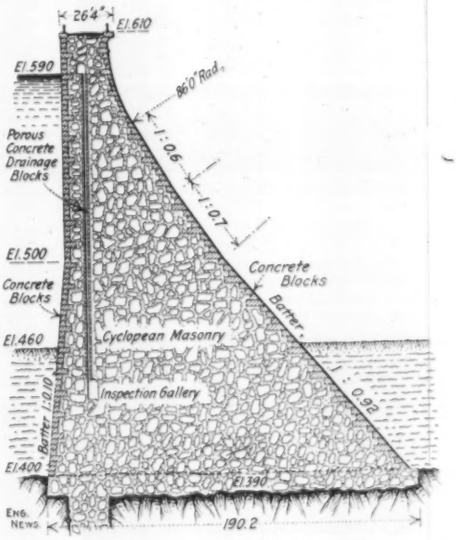


Fig. 3. Maximum Cross-Section of Olive Bridge Dam.

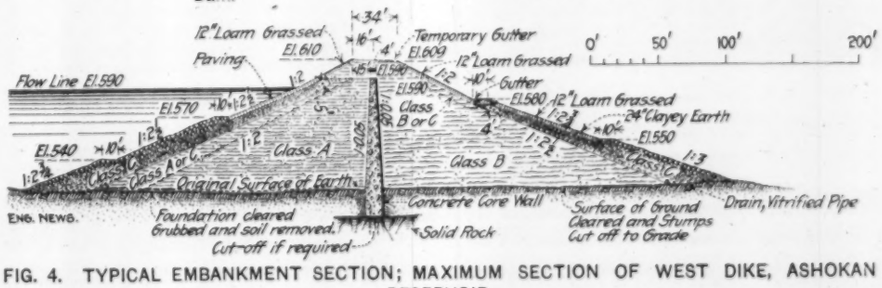


FIG. 4. TYPICAL EMBANKMENT SECTION; MAXIMUM SECTION OF WEST DIKE, ASHOKAN RESERVOIR.

AN EXPERIMENTAL TEST OF A RAILWAY TERMINAL SYSTEM.

It is easy to test the ideas of the inventor of an ordinary tool or appliance by making the invention and trying it in actual operation. Even when the invention reaches large proportions, such as a locomotive or a submarine vessel, plenty of capital is the sole requisite to demonstrate the truth or falsity of the inventor's claims. But when a man invents a plan for operating a railway terminal it is a very bold traffic manager indeed who will run the risk of failure and consequent confusion and risk of panic and disaster by putting into use anything wholly novel and untried. Still again, when the inventor proposes to radically alter the system of moving trains in the busiest and most crowded terminal in the world—that at the Manhattan end of the Brooklyn Bridge—the problem of making actual trial of the invention is a most knotty one.

Many years ago, Mr. Neils Poulson, an architect of Brooklyn, invented a system of operating the Brooklyn Bridge terminal which he believed was far superior to any then or since in use. At frequent intervals ever since, the "Poulson plan" has been urged upon the public and the engineers responsible for the safe movement of traffic over the bridge as a panacea for the ills under which Brooklynites have long groaned. The Poulson plan has at various times been supported and advocated by various newspapers, trade and civic associations, and influential citizens, who were convinced that Poulson was the Moses to lead the Brooklyn Bridge crowds into the Promised Land where a seat for every passenger should be the rule.

Appeals from these respectable sources induced the Board of Estimate of New York City to order a test made upon the Poulson system under direction of the Board's Chief Engineer, Mr. Nelson P. Lewis, M. Am. Soc. C. E. The report printed below gives the result of this test, which was carried out at Coney Island last month.

Hon. George B. McClellan, Mayor, Chairman of the Board of Estimate and Apportionment:

Sir—On April 5 the Board of Estimate and Apportionment instructed me to make a practical test of the operation of trains by means of a four-track stub-end terminal at the Culver Depot of the Brooklyn Rapid Transit Company at Coney Island. I was also instructed to invite at least two engineers or laymen to witness this test, who should join with me in presenting our report and conclusions to the Board.

Mr. Poulson was requested to suggest several men who would be satisfactory to him, and Mr. F. Stuart Williamson, who was one of those named, was invited by me and was present at all of the tests made. I also invited Mr. A. J. Neafie, who is in charge of the terminals of the Delaware, Lackawanna and Western R. R., and who was recommended to me as a man thoroughly conversant with terminal problems and track arrangement at terminals. Mr. Neafie brought with him several members of his staff to observe the train movements, the operation of switches and signals, etc. The tests were

made on April 21 and April 28, and are made the subject of a joint report herewith submitted.

Respectfully,

Nelson P. Lewis, Chief Engineer.

Hon. George B. McClellan, Mayor, Chairman of the Board of Estimate and Apportionment:

Sir—In accordance with the authorization and instructions of the Board of Estimate and Apportionment at its meeting held on April 5, 1907, we beg to submit the following report of a test of the operation of a four-track stub-end terminal at the Culver Depot of the Brooklyn Rapid Transit Company, at Coney Island.

The first test was attempted on Sunday, April 21, in accordance with a schedule prepared for the purpose after a consultation with Mr. Poulson. This schedule provided for the division of all trains entering the terminal into two principal groups, each with an equal number of trains, and two pockets, with a common loading platform to be assigned to each group, so that all passengers would know that they could always reach from the same platform any particular train running on one of the seven different lines now operated. This arrangement was agreed to by Mr. Poulson, who wrote on April 11 as follows:

> It should be, as you correctly say, that all trains will be divided into two groups, and trains belonging to the same group can occupy either one of two tracks assigned to that group, so that a train for any destination can be reached from one of two loading platforms, although it may be on either side of that platform.

The test was conducted on these lines for about nine minutes, when, owing to the large number of cars in motion, the feed wires burned out and we were unable to proceed further. During these nine minutes of operation, trains were handled at the rate of about 42 an hour.

Another test was made on Sunday, April 28, the feed wires having been reinforced and the number of trains used having been largely reduced by the introduction of an additional crossover between the inbound and outbound tracks. The method of operation on the 28th was in every particular in accordance with a schedule outlined by Mr. Poulson. Three different operations were performed:

First—Four trains standing on the inbound track were run into four empty pockets as quickly as possible.

Second—Four trains standing in the pockets were run out in sequence as quickly as possible.

Third—Three pockets were filled and one pocket was empty, with a train standing in front of the semaphore guarding the main switch leading into the terminal. Trains were then run in and out of the terminal in sequence as rapidly as possible for half an hour.

The time consumed by four trains entering the terminal, counting from the time the first train passed the home signal to the time the fourth train came to rest in its pocket was 2 min. 30 sec. The time consumed by these four trains in leaving the terminal, counting from the time the first one started from rest to the time that the rear of the last one passed the home signal, was 2 min. 33 sec.

We are unable to say what significance can be attached to this test. If it were proposed as a method of operation, that is, if four empty pockets were filled and then emptied before other trains were admitted, the time for receiving and dispatching these four trains was 5 min. 9 sec., or an average time of 1 min. 17¼ sec. per train, which is at the rate of 46.6 trains per hour. Under the third method of operation 28 trains were received and dispatched during the test. Careful records were taken at every point where information could be obtained to test the efficiency of this method. These observations have been carefully compiled, and show the following results:

Ingoing Trains.

Average time elapsed between the clear signal and the passage of the head of train at the semaphore, 3.5 sec.
Average time of train passing semaphore, 22 sec.
Average time between head of train passing semaphore to train at rest in pocket, 42.3 sec.

Outgoing Trains.

Average time between clear signal and start of train, 2 sec.
Average time from starting to arrival of head of train at semaphore, 19.1 sec.
Average time of outgoing train passing semaphore, 18.3 sec.
Average headway between trains entering pockets 3 and 2 and pockets 2 and 1, 44.4 sec.
Average headway between trains entering pockets 1 and 4, 93 sec.
Average headway between trains entering pockets 4 and 3, 87.1 sec.
Elapsed time between trains 1 and 28, 29 min., 54 sec.
Average headway between trains, 66.4 sec.
Number of trains per hour at this headway, 54.2.
Maximum time of train at rest in pocket, 3 min., 15 sec.
Minimum time of train at rest in pocket, 2 min., 50 sec.
Average time of train at rest in pocket, 3 min., 1.6 sec.

It will be noted that the headway between trains entering pockets 1 and 4 and between trains entering pockets 4 and 3 is much greater than that between other trains. Between pockets 1 and 4 there is an interference which is unavoidable under any plan, either that proposed by Mr. Poulson or by the Department of Bridges.

There was also an interference between pockets 4 and 3, which it was impossible to avoid at the Culver Depot without special track construction and long delay. It is avoided, however, both in Mr. Poulson's plan and in the plan which the Department of Bridges proposes to follow. It is possible to estimate, however, what could have been done without this interference.

The average headway between pockets 4 and 3 was 87.1 sec. The average headway where there was no interference was 44.4 sec., or 42.7 sec. less than on each of the seven train movements between pockets 4 and 3, or a total loss of 4 min. 59 sec. Without this interference, therefore, it might have been possible to have reduced the elapsed time for handling 28 trains to 24 min. 55 sec. This would have resulted in an average headway for 27 intervals of 55.37 sec., equivalent to a capacity of 65 trains per hour.

It has also been claimed that, owing to the use of the overhead trolleys, instead of the third rail, the speed of the trains in the terminal was less than it would be at the Brooklyn Bridge terminal, where the third rail is used. The Brooklyn Rapid Transit Company had a man at each of the three trolley poles with which each train was provided, and while the trolley wheels frequently left the wire, there was little loss of speed due to this cause. It has been shown that the average time required for an ingoing train to move its length past the home signal, practically from rest (the average interval between the clear signal and arrival at semaphore being but 3.5 sec.), was 22 sec., and that the average time consumed by an outgoing train moving its own length past the home signal was 18.3 sec. In order to compare this speed with that obtained at the Brooklyn Bridge, the time consumed by empty five-car bridge trains moving their length from rest at the unloading platform in the Manhattan terminal has been carefully observed. During the evening rush hours this time was found to be 22 sec., precisely that of the ingoing six-car trains at the last test. During the morning rush the average time from recent observations was found to be somewhat more than 25 sec. It appears, therefore, that the train speed of the six-car trains at this test was actually greater than that of the five-car trains now operated on the Brooklyn Bridge, so that no allowance should be made on account of the greater speed which could be obtained from the use of the third rail.

Reports from men stationed in the signal tower and at other points at the Culver Depot indicate that the switching and signaling plant is up to date, and was operated to its maximum efficiency. The principal operating officials of the Brooklyn Rapid Transit Co. were present, and it can be safely said that everything possible was done to develop the maximum efficiency of the method of operation which was used, and it is doubtful if this same efficiency could be maintained. The allowance made for avoidable interference between pockets 4 and 3 indicate, therefore, that the greatest number of six-car trains which could be handled in a four-track stub-end terminal would be 65 per hour. This result was accomplished with empty trains, without regard to schedule or destination. If the trains were divided into two groups, in accordance with the arrangements for the test of April 21, and if trains from seven different lines arriving at the Brooklyn end of the bridge could be sent across the bridge in sequence of pairs, that is, two of Group A, followed by two of Group B, and again by two of Group A, etc., the same sequence of movement used at the test might be realized. Trains will not arrive in this order. Mr. Poulson maintains that they can readily be held at the Brooklyn end of the bridge and despatched in this order. This is an operating problem which those who are familiar with train operation with whom we have consulted declare to be exceedingly difficult, if not impossible. If it were possible, we would still be confronted with the awkward problem of loading from one island platform, passengers for four different destinations on trains whose headway varies from three minutes to fourteen minutes.

On Saturday afternoons when through trains are operated, and two trains bound for different points are loaded from the same platform, the interference between passengers desiring different trains and the car door crush are quite as bad as during the rush hours when bridge trains only are operated. If four different trains, instead of two, were to be loaded from one island platform, with uncertainty as to the side of this platform at which any train would arrive, with crowds surging from one side to the other as a train for a certain line enters a pocket, it does not require much imagination to see in these conditions elements of danger which would probably result in serious accident.

It should also be remembered that to avoid loading and unloading from the same platform, which we consider to be entirely impracticable, it will be necessary to separate the present central tracks, introducing between them an unloading platform and reducing the present width of the two island platforms which would be used for loading.

An alternative method of operation and loading has been proposed, namely, to run the trains in sequence regardless of their destination. This involves holding back the crowds on a concourse back of the pockets, admitting those desiring a certain train when such train is in the pocket or is about to enter. As any train may enter any one of four pockets, and may be reached from either one of two loading platforms, and as the waiting for a particular train would be scattered throu all parts of the waiting crowd, we believe that here ain we would have conditions productive of confusi danger and panic. We believe that with the enorm crowds which are handled on the Brooklyn Bridge, t streams of passengers moving to their trains must b uninterrupted, that if they are to be grouped accordin to destination, there must be a definitely fixed pla for the waiting of those having the same destination, d that alternate checking and releasing of this hu flood would be dangerous in the extreme.

We believe that the problems of handling larg crowds are intricate and difficult, and can be solved only by those who have had extensive experience in this particular work.

Our conclusions are as follows:

1. That with a four-pocket stub-end termi with two loading platforms, with trains operated in two groups, so that the same train could always be reached from one or the other side of the same platform, and with trains entering as they arrive at the Brooklyn end of the bridge, it might be possible to handle 50 trains an hour.
2. That with the same arrangement, but with trains sorted at the Brooklyn end of the bridge, so as to arrange them in sequence of pairs, it would be possible to handle 60 trains an hour, provided the trains could be despatched from Brooklyn at that rate when so grouped.
3. That if trains are run in sequence and the pockets are occupied in order, without regard to destination of trains, it might be possible to handle 65 trains an hour, provided the highest degree of efficiency can be maintained.
4. That the control and safe handling of passengers in such a terminal would be extremely difficult, if indeed it would be possible; that responsibility for the safety of those using the bridge rests with the operating company and the Department of Bridges, and that we cannot advise the adoption of any plan which would nullify that responsibility or force upon them a method of operation which is in conflict with their judgment and the experience gained from more than a score of years of operation of the bridge with almost complete immunity from serious accident, a record which in this respect is unequaled.

Respectfully submitted,

Nelson P. Lewis, F. Stuart Williamson, A. J. Neafie.

A DECISION ON RATES OF PAY FOR STEAM SHOVEL MEN AND ENGINE RUNNERS ON THE PANAMA CANAL WORK.

On March 1 last application was made for an increase in the rates of pay for several classes of skilled workmen now engaged on the Panama Canal as follows: Engineers to be increased from $210 to $300 per month; cranemen, from $185 to $250 per month; firemen, from $83.33 to $110 per month.

Decision on the application has just been made by Secretary Taft, and in refusing the desired increase, an interesting statement is made concerning the present rates of pay for the several classes of labor named. We quote from the statement as follows:

> A careful examination into the rates of pay prevailing throughout the United States shows that some four years ago the usual rates of pay for steam shovel engineers were $125 a month, and for cranemen $80, but that in the interval since the enormous demand for new construction has increased the wages of both, so that the average throughout the country may be said to vary from $100 to $110 for cranemen and from $150 to $160 for engineers. Mr. Shonts and Mr. Stevens have prepared tables of the wages paid by various firms in the United States, and these rates do not differ essentially from those submitted by Mr. Dolan, the chairman of the Brotherhood of Steam Shovelmen.
>
> The average wages paid by four of the largest firms of the United States, including O'Rourke & Co., White & Co., MacArthur & Co., and Oliver & Co., as stated by themselves, show a rate of $150 for engineers, $88 for cranemen, and $57 for firemen. The average of eleven large firms in the United States, submitted by Mr. Dolan, from San Francisco to New York and from New Orleans to Chicago, shows a rate of $110 for cranemen, $163 for engineers, and $71 for firemen.
>
> Taking the figures submitted by Mr. Dolan, an average of wages paid by 81 firms throughout the United States would be $102 for cranemen, and for engineers $152. In New York, where the rate of living is higher, there are engineers who receive $175, and cranemen proportionately less. In work on the Mississippi, as high as $200 a month is paid shovel engineers, and the employment agent of the commission at Pittsburg reported early this year that the demand was so great that the wages of engineers were tending toward $200 per month. In Alaska the rate for engineers is reported to be $300 and for cranemen $250.

It is a little difficult to fix a uniform rate, because in many cases the contractor is able to compare the efficiency of his steam shovel engineers by the daily yardage produced by each, and is able, therefore, in his own interest to increase the pay of the more efficient, so that the high rates mentioned are frequently not class or average rates, but rates for special individuals. Upon the Isthmus the conditions under which the different men work in respect to the character of the material and the distance of the dumps are so different that it has been impossible to graduate the pay, or offer bonuses for high yardage. The only method is to fix a flat rate for the whole class.

After giving the matter the consideration which its importance deserves, and after weighing the comparative advantages which the Isthmian shovelmen enjoy over their brothers in the States, with the disadvantages which they have to bear in going to and living on the Isthmus, I have reached the conclusion that the existing standard of pay for the shovel engineers, and, a fortiori, for the cranemen, is a liberal one, and ought not to be increased, except under some provision of reasonable increase applicable to all veteran skilled employees of the commission who are paid by class rates. As already seen, the rates paid to the Isthmian shovel engineers are certainly from 25 to 35% higher than the average of those paid in the States, and this by no means states all the difference in favor of the Isthmian terms of employment.

A steam shovelman on the Isthmus can count on twelve months' constant employment in a year, and steam shovelmen in the United States cannot expect to be employed more than nine months in the year. This arises from the interference with contract work in the United States by winter conditions, and also by the necessary intervals arising between change of contracts. Mr. Stevens' estimate is that every steam shovelman in the States should count on a loss of four months instead of three in each year. However, for the purpose of the argument, we can leave it at nine months. The rate of pay for steam shovel engineers in Alaska, as before stated, is said to be $300 a month, but we are not advised as to the circumstances surrounding this employment, except that we can reasonably presume that the working year there would hardly exceed six or seven months.

Second—Every shovelman on the Isthmus is entitled to six weeks' leave with pay as a vacation, so that he receives 12 months' pay for 10½ months' work.

Third—Steam shovelmen on the Isthmus work but eight hours a day, whereas many, though not all, of the steam shovelmen in the United States work for ten hours a day.

Fourth—Every employee of the Isthmus is permitted, if he falls sick, to enjoy 30 days' sick leave with pay.

Fifth—In addition to the sick leave, if the employee receives an injury during his work, he is entitled to an additional 30 days' sick leave.

Sixth—Every married man is entitled to furnished quarters for himself and family free, with modern plumbing conveniences, with water, fuel, and light free; and a commissary which aims to sell all necessaries at cost to commission employees. The married quarters are generally in separate houses. Every bachelor is entitled to his furnished room free, together with light and board at a reasonable rate at a mess house or hotel. The cost of food and necessaries is about what it is in Eastern cities, or slightly higher.

Seventh—Every employee is entitled to free medical attendance and hospital service. The medical visits of the commission physician, after the first, have involved a charge of $1 each, but Col. Goethals advises me that this is to be dispensed with.

Mr. Dolan says that if quarters are desired, many of the contractors in the United States will furnish them; but it goes without saying that these quarters are of a most temporary and unsubstantial character, and do not compare with the really comfortable homes which are furnished to shovelmen and their families on the Isthmus, and none of the other advantages are furnished free by contractors, so far as the testimony of the contractor goes.

It may be that service on the Isthmus is attended with greater discomfort and greater risk of illness than that in the States, due to the climatic conditions, and that the distance from home, the difficulty of securing usual and rational amusements, and the naturally depressing effect of continued high temperature makes the service on the Isthmus less desirable than that in the United States. But it is to be remarked that the original conditions of unhealthfulness which existed when the original rate for shovelmen was fixed in 1904 have been greatly bettered, that the yellow fever has been stamped out, that the rate of death and sickness among Americans is exceedingly low, and that life on the Isthmus is becoming more and more like that in the United States, and this improvement is certain to continue. The opportunity to visit the United States each year, if improved, is a great aid in maintaining health.

It has been urged that service on the Isthmus so undetermines the health of the steam shovelman that he is utterly unfitted for work in the United States when he returns. I cannot agree with this view. The health statistics and the general condition of the Americans on the Isthmus refute the claim.

It is also said with truth that service under the commission is attended with a possible risk of personal injury, due to the negligence of superior officers, damages for which are not recoverable under the law from the commission, while such injuries as are due to the negligence of contractors in the United States, entitles employees of the contractors to compensation.

It is, of course, difficult to weigh the money measure which should be allowed for the disadvantage which American laborers and employees on the Isthmus have to bear, but one must be arrived at; and, after giving full effect to all the considerations stated, I am strongly of opinion that the rate of wages on the Isthmus, taken with the advantages which are enjoyed by the shovelmen on the Isthmus under their terms of employment, are sufficiently in excess of the annual rates of wages in the United States fully to make up for the greater strain and risk upon the employees on the Isthmus. There is a difference in favor of the Isthmian flat rate of wages of from 25 to 35%, while the certainty of twelve months' employment out of the year, the six weeks' leave with pay, together with free quarters, free fuel, and free light, and free medical attendance, carry the advantage of the Isthmian rates of wages expressed in percentage easily to 75%. Mr. Shonts and Mr. Stevens make the percentage considerably over this.

There are not more than 70 steam shovel engineers and not more than 70 cranemen on the Isthmus, and the additional expenditure to which the government would be put in increasing their wages might be comparatively small; but the truth is that the rates of wages paid to the steam shovel engineers is regarded on the Isthmus, and properly regarded, as the basis for fixing the rates of all the other American construction employees who are paid a class rate. I quite realize the embarrassment and interference with the progress of the work which would arise if the steam shovelmen withdraw from the service of the commission and that the injury would be greater to the commission than to an employer whose source of labor supply is nearer at hand; but it seems to me that the figures I have given above show that the request of the steam shovelmen that their wages be increased over the present liberal standard is not responsible; and that if these demands be yielded to for fear of their withdrawal from the service, a precedent will be set which in the end would work much more injury to the work than the embarrassment that might arise now from their withdrawal.

While the increased pay asked is not granted, an order is recommended, and was put in force on May 1, giving a yearly increase of 3% of the class or basic rate to all skilled workmen, engineers, conductors and mechanics from the United States. It will be necessary for an employee to have served one year in a certain class to be entitled to this increase. This will furnish an incentive to steady work and continuance in the service.

Regarding the matter of summary dismissal without a hearing, Secretary Taft says that he has given his approval to the plan of Col. Goethals whereby it is proposed to dispose of such cases through a committee consisting of one representative of the craft of the employee proposed for dismissal, one representing the foreman or high official proposing discharge, and one representing the commission, final action to be taken by the commission.

DAMAGE BY AN ICE SHOVE ON THE OTTAWA RIVER.

Those of our readers who are familiar with conditions in the extreme North are aware of the danger that besets structures exposed to the movement of ice, such as bridge piers. On the lakes and rivers of Canada ice forms at times to a thickness of several feet and when a sheet of this ice is moved by the force of winds or of currents the pressure it may exert is limited only by the crushing strength of the ice. Prior to the construction of the Victoria bridge at Montreal it was supposed to be impossible to place a pier in the St. Lawrence that could withstand the shove of the ice sheet.

BOAT HOUSE IN BRITTANIA BAY, ABOVE OTTAWA, ONT.; WRECKED BY AN ICE SHOVE, APRIL 19.

We illustrate herewith a case of damage done by a field of ice on the Ottawa River about eight miles above the city of Ottawa. At this point the river expands into a broad bay two or three miles in breadth, and shallow for a long distance out from the shore. An amusement park is located on this bay and a long pier extends out to deep water with a club house and boat house built on piles at its outer end. Recently the heavy sheet of ice, some 3 ft. in thickness covering the bay, began shoving against the club house, and the results are shown in the accompanying cut, from a photograph taken on April 19. The floe of ice which did the damage was about 7 sq. miles in area. We are informed that the structure will have to be entirely rebuilt.

In our issue of Jan. 12, 1893, we published an account of the movement and destruction of several bridge piers by the pressure of ice sheets. These piers, we may note, were all located in Canadian waters. In the same issue was given a full discussion of the causes of ice shoves and of the methods of design required to make a structure stable under such conditions.

REPORT OF THE CALIFORNIA DEBRIS COMMISSION.

The California Debris Commission has recently submitted its annual report to the War Department. The Commission was created in accordance with a Congressional act of 1893. The present report is signed by Col. W. H. Heuer, Maj. C. H. McKinstry and Maj. William W. Harts. The Commission was appointed to study and in some degree to rectify the damages done by the deposition of mining debris in certain of the river basins of California. In our issue of Jan. 15, 1903, we described some proposed barriers for retaining hydraulic mining debris carried by the Yuba River. Brief notes relating to this work were published in our issues of April 23 (p. 363) and Dec. 17 (p. 554), 1903. The work done in accordance with this early plan not proving permanent, further construction of more substantial character was undertaken. The later work was described in Engineering News of June 15, 1905, under the title "Debris Barrier No. 1, Yuba River, California." In general, both the earlier and later work involved what may be termed a self-built hydraulic-filled dam; that is, a low dam was built across the river, and after debris carried by the stream had filled in behind the dam another one was built slightly back of the first one, and so on until the desired height was reached.

In our issue of March 9, 1905, a lengthy report on the rectification of the Sacramento and San Joaquin Rivers was published. This report was made by a commission of engineers appointed in 1904, as a result of a State River Convention held under the auspices of the River Improvement and Drainage Association of California.

In the present report of the Debris Commission, it is stated that the low-water surface of the rivers under its jurisdiction has been raised from 7½ to 15 ft., and that it was necessary to devise means to restore the rivers, so far as possible, to the conditions existing before 1860. Certain conclusions and recommendations given in the report are as follows:

That it is inadvisable to attempt to divert the Bear or American Rivers into the "tule" lands.

That it is inadvisable to construct settling basins and restraining barriers in the lower courses of the Bear and American Rivers.

That it is now time to commence the work of restoring the navigable conditions of 1860 in the Sacramento and Feather Rivers, and that the most feasible and advantageous method of accomplishing this is by dredging.

In pursuance of these conclusions and in compliance with the requirements of the act of March 1, 1893, the Commission recommends as follows:

That an appropriation of $400,000 be made by Congress, contingent upon a similar appropriation being made by the State of California, part of this sum to be devoted to the construction of two hydraulic dredges of high power, and the remainder to their operation and maintenance, in accordance with the general terms of this report, for improving the navigability of the Sacramento and Feather Rivers, and for disposing of the mining debris brought into them by their tributaries.

That these funds be expended by the California Debris Commission under the direction of the Secretary of War, all rights of way and easement for levees and spoil banks to be furnished free of cost to the United States.

REPORT ON THE FOUNDATION MATERIALS FOR THE PANAMA CANAL LOCKS.

The last important criticism of the Panama Canal plans, the claim that there exists no safe, satisfactory material on which to found the great locks, has been investigated within the past month by Secretary-of-War Taft and a commission of Consulting Engineers. The report of these engineers to Secretary Taft gives complete assurance of the possibility of "a safe and stable foundation" at every lock site. This report, reprinted below, refers specifically to the lock sites only. The question of foundations for the Gatun Dam has also been studied by the commission, but its report on this subject, necessarily dealing with more extensive details, has not yet been transmitted. We have reason to believe, however, that it will be fully as reassuring as the present report on the lock sites.

Hon. William H. Taft, Secretary of War,
Washington, D. C.

Sir: At your request we went with you to the Isthmus of Panama, arriving there on March 30, 1907, and examined the sites proposed for the locks of the Panama Canal, and we beg to report that we found that all of the locks, of the dimensions now proposed, will rest upon rock of such character that it will furnish a safe and stable foundation. A detailed statement of the results of our examinations accompanies this report.

Respectfully submitted,
Alfred Noble, Frederic P. Stearns, John R. Freeman,
Consulting Engineers.

New York, May 2, 1907.

Detailed Statement of the Results of the Examination of Lock Sites.

GATUN LOCKS.—At the site of the Gatun locks five test pits, each about 6 ft. square, had been sunk to or below the level of the foundations of the lock walls. The deepest pit had a depth of 87.4 ft.

We individually went down into each of the test pits and found that for a distance of a few feet below the ground surface the pits passed through clay; then entered and continued in rock to the bottom. The pits were timbered through the clay and in one or two cases for a few feet below it; below the timbering the rock was standing well in the vertical walls, notwithstanding the blasting required in excavation.

With one exception the rock was a fine-grained bluish-gray rock which Mr. Ernest Howe, the geologist who had been making an extended examination of the lock sites, designates as an argillaceous sandstone. It is the same material that has often been referred to as indurated clay. In hardness it may be compared with some of the clay shales, but is massive rather than laminated. The exception mentioned was a conglomerate rock found in the lower 8 ft. of Test Pit No. 1, which was not quite so hard as the fine-grained material above it. A small amount of water filtered into each of the pits through the fine-grained sandstone and a somewhat larger quantity into Pit No. 1 through the conglomerate. In no case was the quantity of water large enough to be of practical importance.

At the time of our visit one test of the supporting power of the rock had been made by loading one square foot of a portion which had been uncovered in making the excavations with 72,000 lbs. of steel rails. This weight, although several times as great as that which would come upon an equal surface under the walls at this lock, caused no appreciable indentation upon the surface of the rock.

Additional tests were made at our request with an improvised apparatus to give a further indication of the ultimate supporting power of the rock. In making these tests irregular pieces of the rock about 5 ins. to 10 ins. across were bedded in sand in a box resting on scales so that the top of the pieces would be substantially level; the top was then made smooth and pressure was applied on an area one inch in diameter, or, if the sample did not fail within the limits of the capacity of the scales, a smaller bearing surface was substituted. Nearly all of the samples tested were taken from the dump beside the test pits where they had been lying for many days exposed to the air and their strength may have been increased or decreased thereby; or they may have been weakened by blasting; but two samples were tested within a few minutes after they were taken from the pits and showed substantially the same results as the others.

Seven samples of the conglomerate from Pit No. 1 were tested and failed at pressures varying from 250 to 1,625 lbs. per sq. in., and averaging 867 lbs. per sq. in. Five samples of the bluish-gray rock from Test Pits Nos. 2, 3, 4 and 5 failed at from 830 to 2,800 lbs. per sq. in., or at an average pressure of 1,688 lbs. Other samples from two of these pits showed no signs of failing at a maximum pressure of 6,000 lbs. per sq. in.

As the pieces of rock were merely bedded in sand those which failed broke in two in all cases; it is therefore probable that the method of testing did not develop the full strength of the rock *in situ* to resist the weight of a load placed upon it.

In addition to the test pits many borings had been made at the site of the locks. Some of these were made with a diamond drill which cut out cylindrical cores of the rock which have been preserved and were shown to us. Other borings or parts of borings were made with a percussion drill which chopped the rock into small pieces that were brought to the surface by a current of water. The material encountered with this drill seems to have been classified on the drawings submitted to us according to the appearance of the particles washed to the surface as "clay, sand and gravel," "sand and gravel," and "sand," but we were assured by those who made the borings that the material encountered in such cases was always a cemented material that was fairly hard. The conglomorate rock which we saw in the bottom of Test Pit No. 1, and which was tested with satisfactory results, was some of the material which had thus been classified as "clay, sand and gravel."

The cores obtained with the diamond drills from all parts of the lock site showed that the rock was of the same kinds as were found in the test pits. All of the rock is of a sedimentary character. The borings have been sufficiently extensive to show that the whole of the locks and at least a portion of the approach will be founded upon the rock. In addition to the examinations by test pits and borings the rock was seen exposed in several places in the excavation for the locks and everywhere appears as a solid compact rock requiring blasting. When exposed to the weather some of the rock disintegrates. This will not affect its bearing capacity. Where an excavation is covered with masonry before the material has been long exposed.

As a result of all of our examinations and investigations we believe the material on which the Gatun locks will rest will afford an ample and safe foundation.

GATUN REGULATING WORKS.—In addition to examining the lock site at Gatun, we also examined the site of the proposed regulating works. We went down into a test pit which had been sunk, and it exposed the bluish-gray argillaceous sandstone found in the test pits at the lock site. Two samples of the rock from this pit when tested failed at 1,240 and 1,470 lbs. per sq. in.

Borings have been made over the site of the regulating works and they show that the rock has sufficient area to furnish a stable foundation for them.

PEDRO MIGUEL LOCKS.—The lock site at Pedro Miguel is so situated that there is a dike of trap rock which will furnish a support for a large part of the length of the lock walls, but either at one end of the lock or at both, according to its location, the walls must rest upon a softer rock quite similar to that at Gatun.

Two test pits had been sunk in the softer rock, one on each side of the trap dike. The walls of these test pits stood without timbering in the same manner as those at Gatun, but the rock appeared somewhat softer than the bluish-gray rock at that place. It has, however, ample strength to support the weight which will be brought upon it by the lock walls.

SOSA LOCKS.—The rock at the site of these locks is shown by several excavations and by borings to be a hard trap rock so that it has been deemed unnecessary to sink any test pits although excavations have been made to a sufficient depth to reach rock at a considerable distance below the surface.

There is no question whatever as to the stability of the foundations at this place, and it seems highly probable that the rock will be so firm that it will not be necessary to build a masonry invert or floor to the locks, except at and near the location of the gates.

Respectfully submitted,
Alfred Noble, Frederic P. Stearns, John R. Freeman,
Consulting Engineers.

May 2, 1907.

NOTES FROM ENGINEERING SCHOOLS.

UNIVERSITY OF CALIFORNIA. — Sixty Seniors in the School of Mines recently made an extended trip of inspection to the Tonopah and Goldfield districts in Nevada.

LOUISIANA STATE UNIVERSITY.—The new chemical building in process of construction will be occupied in the fall of 1907. It is of reinforced-concrete construction, faced with brick, and is 155 × 70 ft. It is three stories high and will provide laboratory facilities for 300 students.

RENSSELAER POLYTECHNIC INSTITUTE.—At a meeting of the Board of Trustees held March 14, courses were established in Mechanical and Electrical Engineering. It was voted to confer the degrees of Mechanical Engineer and Electrical Engineer on graduates of the new courses.

WORCESTER POLYTECHNIC INSTITUTE.—All equipment has been rearranged for electric transmission of power. The shop machinery has been divided into groups which are run by five and ten-HP. two-phase motors. In arranging the shop groups, floor space has been reserved for additions; and as any motor becomes overloaded, the group which it drives will be divided.

HARVARD UNIVERSITY.—On Monday, April 29, and Friday, May 3, Major Leonard Darwin will give the third and fourth lectures in the series on Municipal Ownership. The third lecture will be on "Municipal Corruption, Wages under Municipal Ownership, the Direct Employment of Labor by Municipalities." The fourth will be on "Municipal Ownership Without Direct Employment, Municipal Ownership and Socialistic Ideals."

NATIONAL ASSOCIATION OF STATE MINING SCHOOLS.—A meeting of this association was held in Lawrence, Kan., April 12 and 13. A bill was prepared for presentation to Congress, providing appropriations from the proceeds of public land sales for the benefit of state mining

schools, similar to appropriations for agricultural colleges. The bill will be presented by the legislative committee, which consists of Victor Alderson, President of the Colorado School of Mines, and Prof. M. E. Wadsworth, of Pennsylvania State College.

COLORADO SCHOOL OF MINES. — The Senior Class started its annual inspection trip April 22, and will spend a month visiting mines and smelters. The itinerary includes Bingham, Park City, Garfield, in Utah; Anaconda and Butte, in Montana.

Carefully kept note-books are required of each student, and these are subjected to daily inspection by the instructors. Outlines, calling attention to all important details, are supplied so that with his attention directed to these points, the student is expected to obtain, personally, the necessary information.

PURDUE UNIVERSITY.—A new Chemistry Building is in course of construction for occupancy during 1907. The building is 70 × 156 ft., of brick and stone, with three working floors and an attic. The building provides laboratory accommodations for 864 students in general chemistry (in six sections), for 100 in qualitative analysis (two sections), 80 in organic chemistry (two sections), 144 in quantitative analysis (two sections) and 20 in physical chemistry, making a total of 1,208.

An automobile testing plant has recently been installed, in response to a demand for accurate information in this line of engineering. The apparatus consists of supporting wheels carried by axles running in fixed bearings so arranged that any automobile may be easily mounted on it. When thus mounted the automobile may be operated as on the road. The energy delivered is absorbed by a friction brake on the axle of the supporting wheels and may be measured by a dynamometer which forms a part of the brake, or by a traction dynamometer attached to some fixed portion of the automobile and which also serves to hold the machine in place on its supports. An electric fan supplies a current of air to the front of the machine, where it may act to lower the temperature of the cooler. The apparatus is supplied with such accessories as are needed for testing gasolene, steam and electric machines.

UNIVERSITY OF MICHIGAN.—At the Marine Engineering Laboratories, model building and testing is done for the Great Lakes ship building concerns. Many boats now running were modeled there, and several to be built this and next season are being experimented with. The work is done in the model room, workshop and tank under the direction of Prof. Herbert C. Sadler, formerly of Glasgow, Scotland.

The process of making these models and determining results is as follows: From the plans of the boat a rough paraffin model 12 to 14 ft. long is cast. This model is fastened to a movable table, bottom up, and certain water lines are marked out on the surface. Then a pair of movable cutters, guided along the sides by the operator, cut the lines into the model at the required depth.

Next the model is turned over to a workman who cuts out the paraffin between the grooves to an equal depth with the machine lines so that the sides are perfectly smooth. After the model is given the desired shape it is burnished and the various water lines are painted on the sides. It is then weighed and placed in the tank, where it is sunk to the required water line by means of shot ballast.

The mechanism on the traveling car which records the movements of the model in the water, consists primarily of an upright rod set on an axis and acting as a lever. The model is attached to one end and the resistance of the model as the car moves is transmitted by this bar through a complicated mechanism to a movable pen which in turn records on a moving drum. At the same time another instrument records the speed so that the speed and resistance are accurately indicated by the record on the drum. The experiments are carried through many speeds, varying from 100 to 800 ft. per minute. Then the various experiments are averaged and the results are obtained. By known formulas these results may be computed in terms of resistance for vessels made of wood, iron or steel. In the same way the power of engines necessary to drive a vessel of the required capacity and speed may be determined.

The experimental tank is 300 × 22 ft. and 10 ft. deep, and is spanned by a traveling motor-driven truck. On this truck are mounted the dynamometers and other instruments for recording the results of tests.

PANAMA CANAL EXCAVATION is progressing by leaps and bounds. Nine months ago some 250,000 cu. yds. were being taken out of the Culebra cut per month, and this was the highest rate of working since the beginning of the American occupation. In February, 1907, the Administration at Washington reported with pride: Over half a million cubic yards were excavated from the Culebra cut in January. A large further increase was made in the next two months. The March record of Culebra was no less than 815,300 cu. yds. And now, according to a telegram from Major Goethals to Secretary Taft, dated May 7, giving the April figure, 879,500 cu. yds. have been reached.

IN THE WRECK on May 1 of a fast train on the Baltimore and Ohio R. R., at Pleasant View, W. Va., twenty persons were injured; two probably fatally. The baggage car left the track, due, it is thought, to defective rail joints; the locomotive and the other five coaches followed it, and the two rear cars went over the embankment.

AN EXPLOSION IN THE WHIPPLE SHAFT of the White Oak Fuel Co., in the Leap Creek district, near Charlestown, W. Va., occurred on May 1; three men are known to be dead, four severely burned, and five others reported missing; 51 men climbed to safety, after the explosion, through another shaft. The explosion is believed to have been caused by ignition of dust by a very heavy shot. Very little damage appears to have been done to the workings, save for that to buildings, etc., at the mouth of the shaft; cages were blown out of the shaft and the tipple buildings were wrecked.

FAILURE OF A CONCRETE ARCH BRIDGE which had just been built but not yet put into service is reported to have occurred at Lowry, near Bedford City, Va., on April 27. The bridge is stated to have had a span of about 100 ft.

A FALLING DAM near Chihuahua, Mexico, on May 2, killed between 15 and 20 workmen and injured 13 others. All of the victims were Mexicans. The collapsed structure was one of the walls of the Chuviscar dam, being built for irrigation purposes.

STORMS IN TEXAS and Indian Territory on May 6 did severe damage. A tornado practically wiped out the Texas towns of Ridgeway and Birthright; telegraphic and telephonic communication were cut off, but press reports state that nine persons were killed and four probably fatally injured. At Temple, Tex., a severe rain and hail storm occurred, lasting forty minutes; lightning struck the plant of the Temple Gas Co., causing an explosion that demolished the reservoir, engine-house and machinery. A similar storm at Atoka, Ind. T., caused great property damage and washed out a section of the Coalgate branch of the Missouri, Kansas & Texas Ry.

DREDGING WORK ON THE DELAWARE RIVER in making a 30-ft. channel from Philadelphia to the sea, which was resumed this spring, is to be advanced at all possible speed so as to complete the entire work before June, 1908. It is thought that if the project is completed by that time, Congress will authorize a 35-ft. depth in the session of 1908-09. Completion of the 30-ft. channel to the full width of 600 ft. fixed in the original project, with the additional work of widening at bends, as now authorized, requires the dredging of about 11,000,000 cu. yds. additional of material. For this work there is now available from federal, state and city appropriations about $2,000,000.

PIER ACCOMMODATIONS IN NEW YORK HARBOR are becoming more and more crowded, especially upon Manhattan Island. In order to relieve this crowded condition the Dock Commisioner has submitted plans to the city for the erection of an entirely new system of docks and piers to be built on the South Brooklyn water front. Nine piers of a combination steel and concrete construction are designed for this place, varying in length from 1,000 to 1,400 ft. and so arranged as to accommodate the largest vessels now entering this port. As soon as the subways to Brooklyn are finished and the transportation problem to and from New York partially solved it is hoped that the great transatlantic lines will see the advantages of these Brooklyn terminals and move their docks from their present crowded situation on the North River both in New York and Hoboken.

THE USE OF TRAIN SPEED INDICATORS is said to be compulsory on passenger locomotives in several countries of Continental Europe and they are largely used on freight locomotives as well.

A GASOLINE-ELECTRIC SWITCHING LOCOMOTIVE or motor car is being used by the Belgian State Railways. It is a four-wheeled machine, resembling an electric locomotive in appearance; its equipment includes a four-cylinder gas engine directly coupled to a generator, and a storage battery which furnishes additional current when necessary and starts the engine by driving the generator as a motor. There are no motors on the axles. An extension of the generator shaft carries two electromagnetic disks, either one of which is excited so as to attach itself to an armature on a sleeve upon the shaft; each sleeve has a bevel pinion gearing with a bevel wheel whose shaft has a spur gear driving a similar gear on a countershaft. The crank arms on the ends of this shaft are attached to the coupling rods which drive the carrying wheels. A third disk on the shaft forms an electromagnetic brake. The engine is of 40 HP. for a speed of 1,000 revolutions, but can be run at 300 revolutions. The machine is designed for use at stations or yards where there is not enough work to keep a steam locomotive in constant service.

THE CENTRALIZATION OF RAILWAY TERMINAL facilities is being brought about in all the large cities in this country as fast as the local conditions will allow. The latest example is Portland, Ore., where a new million-dollar union passenger depot has been projected for all interurban and suburban trolley lines in and about the city. This unification of all trolley car terminals is rather a new departure in street railroading and should be a great step toward advancing the usefulness of the separate systems.

LAKE WALCOTT, the artificial body of water created by the Minidoka dam of the U. S. Reclamation Service, is the largest lake in southern Idaho. It is 35 miles long and over two miles wide for seven miles of its length. The country about it was a desert solitude three years ago, but now supports a population of 10,000.

PERSONALS.

Mansfield Merriman, Professor of Civil Engineering in Lehigh University, has tendered his resignation to take effect on September first.

Mr. Clifford S. Sims, formerly Assistant to the President of the Erie R. R., resigned on May 1 to become General Manager of the Delaware & Hudson R. R.

Mr. W. A. D. Short has been appointed Chief Engineer of the Continental Signal Co., of Chicago. He was formerly in business there as a consulting signal engineer.

Mr. Nelson Davenport, City Engineer of Boise, Idaho, has resigned to become associated with Mr. Godfrey Sperling, in the firm of Sperling & Davenport, consulting civil engineers, with offices at Boise.

Mr. Edwin C. Holden, M. Am. Inst. M. E., has become associated with the firm of Hill & Irvine, mining engineers and geologists, New York. The firm name will henceforth be Hill, Holden & Irvine.

Mr. C. W. Kouns, Superintendent of Transportation of the Atchison, Topeka and Santa Fe Ry., with headquarters at Chicago, has been appointed Assistant to Mr. J. W. Kendrick, Second Vice-President.

Mr. E. J. Willis, who for years has held the position of Superintendent of the South Side Water-Works, Pueblo, Colo., resigned on April 23; Mr. A. G. Wagner, former Deputy County Clerk, was elected as his successor.

Mr. Charles W. Wells has resigned as Deputy State Engineer of Colorado to accept the position of Chief Engineer of the Phelps-Dodge Co. in the construction of their railroad from Colima, Mexico, to the Pacific Coast.

Mr. C. B. Stanton, graduate of Rensselaer Polytechnic Inst., 1903, has been appointed Associate Professor of Civil Engineering at Iowa State College, Ames, Iowa. He will be in charge of the Department of Railway Engineering.

Mr. William Miller, formerly Assistant Superintendent of Motive Power of the Denver & Rio Grande R. R., has been appointed Superintendent of Motive Power of the Western Maryland R. R. to succeed I. N. Kalbaugh, resigned.

Mr. Charles W. Reinhardt, Chief Draftsman of Engineering News, gave a lecture on April 19 before the Engineers' Club of the Sheffield Scientific School of Yale University, on "A Rational Method of Lettering as Applied to Working Drawings."

Mr. C. W. E. Clarke, formerly Assistant Engineer with Sargent & Lundy, Mechanical and Electrical Engineers,

of Chicago, has resigned that position to accept an appointment as Steam Engineer with the New York Central R. R., at New York.

Mr. A. R. Holliday, Engineer of Maintenance of Way of the Indianapolis terminal division of the Pennsylvania R. R., has resigned. Mr. F. H. Watts, who has held the same position on the Michigan division of the Vandalia R. R., will succeed him.

Messrs. Frazier, Fox and Spencer, consulting engineers, of Cleveland, have dissolved their partnership through the retirement of Mr. J. C. Spencer. Messrs. J. W. Frazier and J. H. Fox will continue as consulting engineers under the firm name of Frazier & Fox.

Mr. Edgar Van Etten will resign as Vice-President of the New York Central & Hudson River R. R., in charge of the Boston & Albany line; the resignation will occur during the coming summer or early fall. He will assume the presidency of the Longacre Electric Light and Power Co., of New York City.

Mr. C. W. Gennet, Jr., former Inspecting Engineer of the Southern R. R., at Pittsburg, has resigned to become the western representative of the Atlas Steel Casting Co., of Newark, N. J., with headquarters at Chicago. Mr. O. A. McQuinn, who has been associated with him in the Pittsburg office, will be his successor.

Mr. N. S. Sprague, formerly Division Engineer of the filtration plant at Pittsburg, was appointed on May 2 to the position of Superintendent of the Bureau of Construction of Pittsburg in place of Mr. E. M. Wilkens. Mr. Sprague has been connected with the filtration plant since the work was begun three years ago.

Mr. John W. Seaver, M. Am. Soc. M. E., has opened an office as consulting engineer in the Caxton Bldg., Cleveland, having resigned as Vice-President of the Wellman-Seaver-Morgan Co. Ten years ago Mr. Seaver, with Mr. S. T. Wellman and the late Charles H. Wellman, formed the Wellman-Seaver Engineering Co.

Mr. F. H. Newell, M. Am. Soc. C. E., Director of the U. S. Reclamation Service, has been designated by Secretary Garfield as the Consulting Engineer of the U. S. Geological Survey, in recognition of his services in building up the engineering work of that department in the direction of measurement of streams and determination of water supply; this work was initiated by Mr. Newell in 1888 and has since been carried on under his direction.

Mr. W. J. Sharp was appointed on May 2 Superintendent of the Rochester Division of the Erie R. R. to succeed Mr. J. C. Tucker. Mr. Robert S. Parsons, former Assistant General Superintendent of the Ohio Division and Chicago & Erie R. R., becomes the Superintendent of the Susquehanna and Tioga Divisions of the Erie, with headquarters at Hornell, N. Y. The office of Assistant General Superintendent at Cleveland has been abolished.

Mr. Herbert M. Wilson, M. Am. Soc. C. E., who was for a number of years Division Engineer on the Irrigation Surveys and later Geographer on the Topographic Survey of the U. S. Geological Survey, has been appointed Chief Engineer of the Technologic Branch of that survey. This branch has charge of the testing of fuels and the structural materials tests for the Federal Government, as well as the supervision of government fuel purchases and the study of smoke abatement. Mr. Wilson is well known as the author of text-books on Irrigation Engineering and on Topographic Surveying.

Major John Biddle, Corps of Engineers, U. S. A., has been relieved from duty as Engineer Commissioner of the District of Columbia and will go to San Francisco, there to become Chief Engineer of the Pacific Division in charge of river and harbor work and fortifications on the Pacific Coast. He has held the position of Engineer Commissioner of the District since Nov. 1, 1901, and has during the period since then done much toward the development of the National Capital in the line of parks, street improvements, water front, etc. Capt. Jay J. Morrow, Corps of Engineers, U. S. A., for four years Major Biddle's assistant, has been promoted to the office of Engineer Commissioner.

Prof. Wm. J. Roberts, Sanitary Engineer of the State Board of Health of Washington, has been appointed Engineer in charge of the works to be constructed by the Chicago, Milwaukee and St. Paul R. R. for the protection of Seattle's water supply in the Cedar River Valley. The sanitary measures controlling construction camps, and for preventing drainage from the roadbed from reaching the water supply, are to be carried out on lines proposed by a commission consisting of Prof. Wm. T. Sedgwick, Dr. Charles Harrington and Dr. A. C. Abbott, and approved by Mr. John R. Freeman, M. Am. Soc. C. E., of Providence, R. I. Articles bearing upon this matter appeared in our issues for Aug. 30 and Dec. 27, 1906.

Obituary.

Edward Gridley, one of the oldest contractors and builders in the vicinity of New York, died at his home in Woodbridge, N. J., on May 5, at the age of 83. He built nearly all of the stations on the Sixth and Ninth Ave. elevated roads.

Walter H. Bryant, prominent in the steel industry, died on May 3 at his residence in Philadelphia. He was formerly secretary of the Latrobe Steel Co., and retired from active business two years ago. He was 57 years of age. His wife and two daughters survive him.

M. L. Hinman, who, with the late Horatio G. Brooks, founded the Brooks Locomotive Works at Dunkirk, N. Y., died at Dunkirk on May 3 at the age of 66. For several years he was president of the Brooks Locomotive Works, and was secretary and treasurer up to the time it was merged with the American Locomotive Co. in 1901. He was Mayor of Dunkirk from 1885 to 1887.

John Milton Hagy, head of the J. Milton Hagy Waste Works at Philadelphia, died at his home in Lansdowne, Pa., on May 4. He was born in 1843; in 1864 he graduated from the Polytechnic College, and as a civil engineer he laid out the town of Oil City, Pa., when oil was discovered in that region. A son and five daughters survive him.

Calvin Brodhead, a well-known Pennsylvania engineer and contractor, and President of the Greenville Silica Sand & Quarry Co., of Greenville, Pa., died of gastritis on April 29 while visiting in New York City. He was prominent in railroad work, having served for some time as Chief Engineer of the Lehigh Valley R. R. In 1872 he superintended the construction of the Easton & Amboy division of that road. At his death he was 61 years of age; three children, a son and two daughters, survive him.

Nathaniel Parks, a pioneer in electrical invention and experimentation, died at his home in Deansboro, Oneida County, N. Y., on April 30, at the age of 82. In his younger days he, in company with Daniel B. Goodwin, of Waterville, N. Y., immersed several miles of wire in the Chenango Canal near Bouckville and made telegraphic experiments to test the practicability of an under-water cable. The information thereby derived was increased by similar experiments on a larger scale in the Harlem River by Mr. Parks and Cyrus W. Field, who in 1855 laid the first Atlantic cable. Mr. Parks took an active part in the arrangements for laying that cable and transmitted some of the first messages sent over it.

ENGINEERING SOCIETIES.

COMING MEETINGS

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 21-24. Annual convention at Philadelphia, Pa. Secy., Richard Moldenke, Watchung, N. J.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22-24. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Semi-annual meeting at Indianapolis, Ind. Secy., Mr. Calvin W. Rice, Engineering Societies Bldg., 33 West 39th St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 4 to 7. Annual convention at Washington, D. C. Secy., W. C. L. Eglin, 29 West 39th St., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 12-14. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, Ont. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19, 20. Annual meeting at Atlantic City, N. J. Secy., P. W. Drew, Wisconsin Central Ry., Milwaukee, Wis.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 20-22. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Annual convention at the City of Mexico, Mexico, beginning July 8. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 25, 26. Annual meeting at St. Paul, Minn. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 14-18. Annual convention at Atlantic City, N. J. Secy., Bernard V. Swenson, 29 West 39th St., New York.

THE AMERICAN SOCIETY OF CIVIL ENGINEERS held its regular business meeting at its house on May 1, 1907, Mr. A. L. Bowman in the chair. The reports of the committees on the Effects of the San Francisco Earthquake of April 18, 1906, on Engineering Constructions were presented for discussion. These committees were organized from members of this society immediately after the earthquake and fire, and were set to work to investigate, from an engineer's view-point, the effect of such catastrophes on all engineering construct... Especially was the study made with a view to th... tering of conditions and the strengthening of all su... nstruction against the further effects of fire or earth... e. The various subjects were assigned to a General ... mittee, and special committees on Geology, Buildin... Water-Works, Lighting and Street Railway Transpor... Sewers, Railway Structures and Highway Structur... In the extended discussion which followed the present... of an abstract of the reports, a number of correspo... s who had been on the ground opposed the conclus... of the Committee on Buildings to the effect that "b... walls, or walls of brick faced with stone, when w... ut an interior frame of steel are hopelessly inadequ... The claim was made that such conclusions are not w...ranted by fact and numerous examples were cited wh... buildings of such type of construction stood up well ... der the earthquake and subsequent fire.

WESTERN SOCIETY OF ENGINEERS.—At ... meeting held at the Society's rooms, in Chicago, ... May 1, a paper on "The Status of the Producer-Gas Po... Plant in the United States" was presented by Mr. R. ... Fernald, Professor of Mechanical Engineering at W...ington University. A considerable part of the paper was devoted to the tests made at the fuel testing plant of the U. S. Geological Survey at St. Louis, Mo., Mr. Fernald being the engineer in charge of the producer-gas tests at that plant. The most interesting part of the paper was that which dealt with comparisons between steam and gas plants, and with various objections which have been made to the gas plant. An endurance test of 24 days continuous run was made at St. Louis, without trouble from heating, clogging of tar, or other trouble. The collection of tar at the water-seal valve, due to an unfavorable arrangement of the piping, made a stop necessary after 24 days, but the engine was found to be in excellent condition and did not even require cleaning. The average brake HP. maintained was 225.5 HP., and the fuel consumption averaged 1.40 lbs. of dry coal per brake-HP. per hour.

About 20 companies are now manufacturing gas producers for power purposes. At least 12 of these are fully established on a commercial basis, and are in position to give proper guarantee when installing plants. About 150 gas-producer power plants, ranging from 20 to 6,000 HP., are now in operation in the United States. One company alone reports over twenty installations averaging over 2,000 HP. each, and nearly as many more (averaging about the same size), contracted for or now being erected. Of the total number of installations about 66% are suction plants which operate on anthracite coal, charcoal being used in a few cases. Bituminous coal is used in approximately 33% of the installations, but these plants probably cover in the neighborhood of 65% to 75% of the aggregate HP. rating.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The spring meeting will be held in Indianapolis, Ind., May 28-31. The headquarters will be at the Claypool Hotel, where 75 rooms have been reserved for convention guests. Members who desire to have accommodations reserved should correspond with the hotel authorities at once.

The opening session on Tuesday evening, May 28, will be chiefly an informal reception. At the second session on Wednesday morning a business session will be held and reports of the Committees on Standard Proportions for Machine Screws and on Refrigerating Machines will be presented. Papers will also be read on "Collapsing Pressures of Lap-Welded Steel Tubes," by Prof. R. T. Stewart; "The Balancing of Pumping Engines," A. F. Nagle, and "A Comparison of Long and Short Rotary Kilns," E. C. Soper. In the afternoon visits will be made to various plants about the city.

The third session, Wednesday evening, will be devoted to automobile interests; the following papers will be presented: "Bearings and Moving Mechanism," Henry Hess; "Air Cooling of Automobile Engines," John Wilkinson; "Materials for Automobiles," Elwood Haynes; "Special Auto Steel," T. J. Fay; "Railway Motor Cars," B. D. Gray.

The fourth session, on Thursday morning, will be chiefly devoted to superheated steam practice, as follows: "The Specific Heat of Superheated Steam," A. R. Dodge; "Determination of Entropy Lines for Superheated Steam," A. M. Greene; "The Flow of Superheated Steam in Pipes," E. H. Foster; "Co-relation of Furnace and Superheated Conditions," R. P. Bolton; "The Heating of Store Houses," H. O. Lacount. The afternoon will be given up to an excursion, and the evening to a reception.

On Friday morning and afternoon, May 31, there will be an excursion to Purdue University, at Lafayette, Ind. A professional session will be held at 10 a. m. in one of the university buildings. The following papers will be presented: "Performance of Cole Superheaters," W. F. M. Goss; "Experiences with Superheated Steam," G. H. Barrus; "Use of Superheated Steam on Locomotives in America," H. H. Vaughan; "Superheated Steam in an Injector," S. L. Kneass; "A Hirn's Analysis of Locomotive Test," S. A. Reeve.